Hands-On AI Projects for the Classroom

A Guide on Ethics and AI

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The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

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Foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, "[Artificial Intelligence] is the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large datasets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in Appendix A: Unpacking Artificial Intelligence.

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from **jmc.stanford.edu/articles/whatisai/whatisai.pdf**

Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority are focused on two general areas: automating administrative tasks like attendance and grading, or increasing student performance and engagement through AI-supported assessment and personalized learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of the *Hands-On AI Projects for the Classroom* series is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users, managers, and even creators of these powerful tools.

So, why devote an entire guide to AI and ethics? Once the stuff of science fiction, AI now permeates nearly every facet of our lives, and while most of us are aware of tools like virtual assistants or AI robots, we may not be cognizant of the many ways that AI is impacting society. For example:

- People routinely rely on AI technologies–like media recommender systems–to make decisions about what shows to watch or what music to listen to.
- Personalization of AI-powered search engine results provides users with unique results based on their previous search results and web browsing behaviors, creating information echo-chambers in the process.
- While students are using social media tools to connect with their friends, AI algorithms are silently collecting data on the profiles they view, which ads they watch, which links they click on, the amount of time they spend in the app, what time of day they use the app, and the location from which they use the app.
- Complex machine learning algorithms are being used by companies to make hiring and firing decisions, often with unintended results.

These examples point out the importance of all students understanding the degree to which AI is being used to influence what and how we learn, how we consume media, and how we solve problems. Awareness at this level does not require specific technical expertise. Educators with little or no prior experience with AI may still help their students become more informed about AI technologies. Educators can help students by identifying instances of AI use, exploring the ethics of machines influencing decisions we make, and thinking about ways that AI technologies impact diverse human populations.

This guide is for all K–12 educators, across subject areas and grade levels. Until recently, conventional wisdom has suggested that instruction about AI should be confined to computer science courses at the high school level and above. However, the use of AI is becoming so pervasive throughout society that a basic understanding of what AI is and what its capabilities are is becoming as necessary as more traditional literacy skills such as reading, writing, and computation. As you will see throughout the activities in the *Hands-On AI Projects for the Classroom* series, AI is truly impacting every field of study, work, and daily life. And while most of the people who will design these tools in the

future may continue to come from math, science, and computer science disciplines, we are all end users and therefore must be participants in the conversation if these tools are to effectively meet our needs.

As you read and teach the projects in this guide, you may be surprised to find that they do not tell students what to believe about what is good or bad, right or wrong, and fair or unfair when it comes to AI technologies. This is by design. Dr. Melvin Kranzberg, a professor of the history of technology at the Georgia Institute of Technology, stated that "technology is neither good nor bad; nor is it neutral." Keeping this statement in mind, this guide asks students to think critically about the impact AI has on society. They will consider the tradeoffs (both good and bad) of various AI innovations and will consider ways that biases and negative impacts in AI might be identified and mitigated. They will also analyze how various AI technologies might affect a wide range of stakeholders, especially those who have been traditionally marginalized by technology or underrepresented in STEM fields. Students will discover that often a technology will have inequitable impacts: positive on some users or stakeholders and detrimental on others. Students will understand that while they might use AI to improve efficiency or accuracy of one task, at the same time they may be asked to give away personal data, civil rights, or personal freedoms in return. This guide asks students to consider timeless ethical questions, diverse perspectives, and even gray areas as they begin to construct their own ideas about how to determine if an AI is ethically developed, designed, and used.

Finally, this guide makes the fundamental assumption that ethical AI is a shared responsibility. Students, teachers, users, programmers, investors, regulators, and others all play a role in determining the future of AI technology development and use. Each project in this guide is an entry point for teachers and students to co-learn and expand their knowledge of the field of AI, and to consider its real and imagined impacts on society. As students engage with the projects in this guide, they will discover their own critical role in shaping how AI technologies are used to solve problems in their life, community, and world.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach

The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their

understanding of how AI technologies work, and create various authentic products—from machine learning models to video games—to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the context of ethical considerations and aligned with standards and concepts, and depths of understanding that would be appropriate across various subject areas and grade levels in K–12. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education, exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in computer science or AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, Project 3: The Tradeoffs of AI Technology can be completed by students in either middle school or high school; however, older students should be presented with deeper instruction on how various AI technologies work and the ethical consequences of how those technologies impact various stakeholders. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI.

The Five Big Ideas in AI (shown in Figure 1) serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

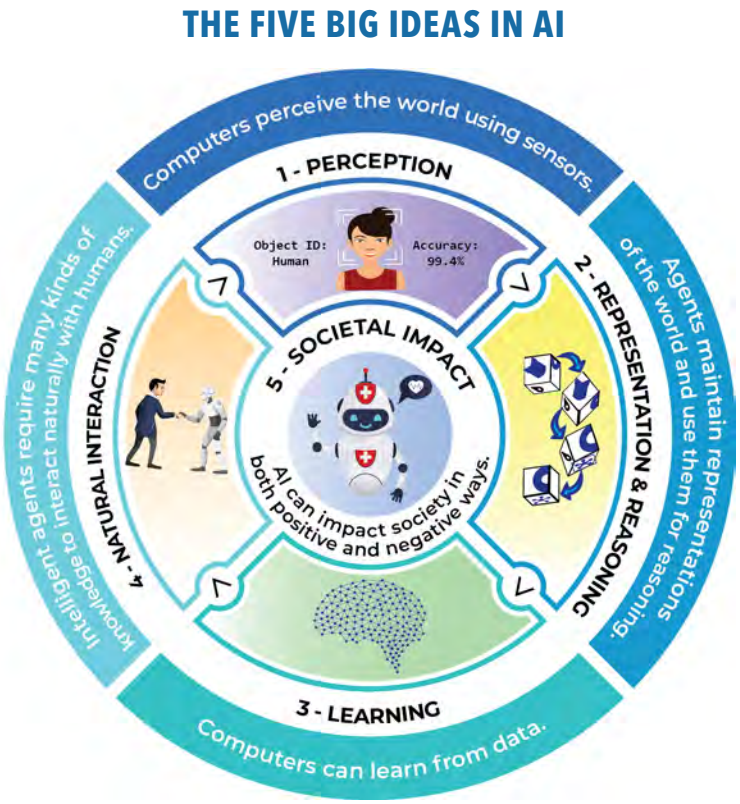

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to

successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model, developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution, Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities, or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both on- and off-line that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendixes. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the *Hands-On AI Projects for the Classroom* series
- A discussion entitled "What Is Artificial Intelligence?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows.

Project Overview

The project overview offers an explanation of what the project is, how it ties to research-based standards. and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject, target grades, and duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

Preparation provides the information educators need in order to put the project into action with students. This section includes a list of materials required for project completion; a list of supporting resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools, reviewing online resources, etc.

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.
- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content.
- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE. ISTE does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Appendices

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in the Hands-On AI Projects for the Classroom series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1
Fair's Fair

Students in elementary school may not be ready to grasp esoteric ethical questions, but most have already developed a strong sense of fairness. Students use this lens as they explore why the quality of datasets used to train artificial intelligence matters.

> This project connects to everyday experiences and is timely. It also outlines how teachers can carry out a conversation following each activity where students get to share their input and opinion as they discuss how AI applications can impact society in a positive and negative way. The activities are inclusive and allow students to share their choices and thoughts regardless of their academic or social background. The extensions also provide teachers in ways they can further student exploration and also adapt lessons to different grade levels.
>
> —Michelle Vehlo, Teacher and STEAM Curriculum Coordinator, Hudson Montessori School

Project Overview

This project introduces some basic ethical concepts related to fairness and equity using data quality and its impact on how machine learning algorithms make decisions and predictions that can impact people's lives.

SUBJECT

Mathematics and English Language Arts

ESTIMATED DURATION

6 hours

TARGET GRADES

K–5

VOCABULARY

artificial intelligence
data
feature
stereotype
survey
training data
unconscious bias

OBJECTIVES

At the end of this project, students will be able to:

- Understand that the ability to accurately represent and interpret data depends on the quality of the datasets being used, and that datasets are created by people.
- Understand that when people make decisions about data used, those decisions may not be fair (i.e. inclusive or representative).
- Understand that predictions made based on patterns identified in data may be helpful, but may also be harmful.
- Understand that these concepts relate to datasets used to train AI.

STANDARDS

ISTE Standards for Students

2. Digital Citizen

b. Students engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

3. Knowledge Constructor

a. Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.

b. Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.

5. Computational Thinker

b. Students collect data or identify relevant datasets, use digital tools to analyze them, and represent data in various ways to facilitate problem solving and decision making.

ISTE Computational Thinking Competencies

1. Computational Thinking

e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. Equity Leader

b. Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.

4. Creativity & Design

b. Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.

AI4K12 Five Big Ideas in AI

3. **Learning**
   Computers can learn from data.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.RI.K.3: With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.

CCSS.ELA-LITERACY.RI.1.3: Describe the connection between two individuals, events, ideas, or pieces of information in a text.

CCSS.ELA-LITERACY.RI.2.3: Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.

Common Core State Standards for Mathematical Practice

CCSS.MATH.CONTENT.1.MD.C.4: Organize, represent, and interpret data with up to three categories

CCSS.MATH.CONTENT.2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a dataset with up to four categories.

Preparation

MATERIALS

- Computer and projection system to share images with students (optional for Activity 1, recommended for Activity 4)
- Drawing materials such as blank paper, pencils, crayons, colored pencils
- Writing materials such as slips of paper, pens, pencils
- Several sheets of chart-sized grid paper
- YouTube Kids app

SUPPORTING RESOURCES FOR EDUCATORS

- Video: "**A Class That Turned Around Kids' Assumptions of Gender Roles!**"
- Article: "**Beyond Gender Stereotypes**"
- Article: "**50 Years of Children Drawing Scientists**"
- Article: "**Siri, Are You My Best Friend?**"

- Article: "**Teaching Artificial Intelligence in Kindergarten**"
- Lesson Plan: "**That's a (Gender) Stereotype!**"

ADVANCED PREPARATION

- Familiarize yourself with the topics addressed in this project by viewing the video, "A Class That Turned Around Kids' Assumptions of Gender Roles!" and reading the articles listed under Supporting Resources for Educators. Moreover, while the project refers to girls and boys at various points, also consider how including other gender references, such as intersex or non-binary, might enhance this discussion and create a more inclusive environment in your classroom.
- If you decide to use screenshots of image searches for Activity 1, prepare those.
- Study the activities and decide in advance how you want to create the surveys and collect responses.
- Set up a parent account for the YouTube Kids app. Despite being asked to, you do not have to associate your Google account with the app in order to use it for Activity 4. (Just ignore that option.) Enable the Search feature before you bypass setting up an account. Spend a little time familiarizing yourself with the app.

Instructions

GETTING STARTED

Activity 1: What are Stereotypes and Unconscious Biases?

In this activity, students engage with the topic of stereotypes and unconscious biases, discovering how they influence people's perceptions in positive and negative ways.

1. Distribute plain paper and tools for drawing (pencils, crayons, or colored pencils).
   - Ask students to draw a picture of a teacher.
   - When they are finished, have students display the pictures so everyone can see them.

   > **NOTE:** This activity can also be done by searching online for images using the keyword "teacher" and projecting the results for students to see and discuss.

2. Stop and Think: Ask students to study the drawings, considering the following questions:
   - What patterns do they see?
   - Are there **features**—unique measurable properties—that they notice in several of the drawings (e.g., what the teacher looks like, what setting the teacher is in, or the teacher's facial expressions)?
   - Do they notice differences?
   - Are there any drawings or images that are completely different from all the rest?

3. Lead a whole class discussion using the following (or similar) questions:
   - How many of the drawings or images show the teacher as a woman? As a man? Why might that be?
   - Are there other features that are similar, such as facial expressions?
   - Are any of the teachers holding an object?
   - What features do people associate with teachers?
   - Do these pictures actually represent all teachers in the world?

   Allow time for students to talk about what they are noticing.
4. Introduce students to the concepts of **stereotypes** and **unconscious bias**.
   - Point out that all people rely on patterns and past experiences to help them make sense of what's around them. These patterns and past experiences often become something called stereotypes, simple ideas we use to describe to ourselves how a person who does a special kind of work might look or behave.
   - Explain that many times these ideas have become such a common way of thinking about these people that we decide we know all about them before we even meet them! This is called unconscious bias, when we form opinions or make decisions about people or things before fully learning about them. Sometimes we decide we like or dislike someone or something just based only on what we think we already know about the person or thing. Provide examples, such as choosing not to play with someone because of the way they are dressed or the way they talk.
   - Ask the following questions:
     - Is it fair to treat people this way?
     - What about deciding not to eat something new because you don't like the way it looks or smells?
     - There are times when that could be a good decision, but what harm could be caused?

> **NOTE:** As a follow-up activity, you could create a learning center where students draw or view images of people in other occupations (scientist, farmer, fire fighter, secretary, etc.) and compare those drawings to identify common stereotypes which we internalize to the point where they become unconscious biases. See also Extension Activity 1.

TAKE A CLOSER LOOK

Activity 2: Best Games Ever

In this activity, students explore the idea that data collected from one group that reflects multiple common features does not necessarily represent members of other, similar groups.

1. Introduce the concept that **data**–information–collected from one group that reflects multiple common features does not necessarily represent members of other, similar groups.
   - Begin this activity by explaining to students that we sometimes make decisions based on unconscious bias, and that this can make people happy or unhappy.

- Point out that people often pick friends who think the same way about what they like or don't like. Then, because the people they are spending time with agree with them most of the time, they start to think that most people think like they do.
- Ask if it is true that all people think alike.
- Say that you are going to imagine how that might work.

2. Tell students they will now have an opportunity to explore this idea further.
   - Ask students to think about their favorite games to play.
   - Brainstorm a list of favorite games with the class and title the list "Best Games Ever."
   - Ask students to think about the following questions related to the list:
     - Would it be fair to say that people of all ages would agree that this list includes all of the best games ever? Why or why not?
     - Imagine that we made copies of this list, gave it to all parents with students at the school, and told them that these are the games their children want as gifts. Would this make all of the students happy? Why or why not?
     - How could the title of the list be changed to make it more accurate? Brainstorm new titles, and discuss whether they are an improvement, and why.
     - How could the list be better? What could be done to make it be more helpful to parents who want a gift list?
3. Guide the conversation to ensure students explore the following questions:
   - Could we collect more data from other students like them?
   - Could we collect data from students of different ages?
   - What other things could we do?

Activity 3: Choosing a Class Pet

In this activity, students begin to explore the concept of representative survey groups and how these groups impact survey results.

1. Ask students if they know what a survey is. Ensure they understand that a survey is used to collect information by asking people what they think or know about something. Point out that the question asked in Activity 2 was one kind of survey. Explain that while this can be a good way to get information, it's important for the person who creates the survey to be careful about who is asked to answer survey questions. Tell students that in this activity they will have a chance to learn why.
2. Tell students that in this activity they will imagine they are going to choose a new class pet. Set the stage by explaining that every student will get to name the kind of animal they want and the kind of animal mentioned most often will be the new class pet. Ask them to think to themselves about what animal they predict that the class will select.

3. If your students are literate, give them each a slip of paper and ask them to write their name, age, and the kind of animal they want as a pet. If your students are pre-literate, ask each one privately for the same information. Record each child's name, age, and answer.
4. Create a bar graph of the survey results. Use the slips of paper or the list you made to create a bar graph of the students' preferences for a new pet.
    - Build an on-the-spot bar graph on a sheet of chart-sized graph paper.
    - Label a column for each kind of animal named.
    - Color one square in that column each time that animal is named.
    - Use colored markers (a different color for each column) to make the differences from one column to the next even easier to see.
5. When you have tallied all the results, ask students the following questions:
    - Is there a clear first choice?
    - Is there a tie?
    - Does the result represent what everyone in the class wants?
    - How could we learn more about students' pet preferences?
6. Create a stacked bar graph that shows results by gender or by age, and ask students the following questions:
    - What happens if we just look at what the boys want or what the girls want?
    - How else could we group responses? (e.g., by age, birthday month, students' eye color, etc.) How would that change the results?
7. Ask students to share their thoughts about the following in a class discussion: Is it more fair to make a decision based on the wishes of all of the students or just some of the students? Why or why not?

Activity 4: Decisions, Decisions

In this activity, students explore surveying **sample groups** and how that might impact the quality of data collected.

1. Remind students that at the end of Activity 3, we discussed if it would be fair to use survey results to make a decision for an entire group if only some members of that group answered the survey questions.
2. Tell students that in this activity they are asked to imagine that all the students in their grade have a chance to help pick new play equipment for recess. Set the stage by explaining that:
    - They will be given a list of five things to choose from: rubber kickballs, jump ropes, frisbees, soccer balls, and hula hoops (you may need to adjust this list based upon location or activity preferences).
    - A survey will be used to find the two most popular items.

3. Explain that there won't be time to survey every student, so the teacher who will order the equipment decides to survey a smaller sample group of students and use their answers to make a decision.
4. Ask students to consider how the teacher should pick the students to survey using the following questions:
    - What do we know about students in our grade level?
    - How many are there?
    - If we ask only the girls what they want, will that represent all the students in this grade?
    - What if we ask only those students who say they like to play ball during recess?

    Point out that decisions made about who to survey can change the predictions made based on survey answers.
5. As a class, create a student survey about new play equipment for recess. Consider the following questions:
    - What information do you need to collect besides favorite equipment?
    - Would it help to know gender? Age? If the student likes recess? Why or why not?
    - What else might be important to know? Note: Keep this step simple and use survey creation and collection tools familiar to yourself and your students.
6. Make a plan for administering the survey.
    - Tell students that since there is not time to survey every student in their grade level, you will help them decide how many students to survey as a sample.
    - Explain that in the real world, 100 surveys is normally the smallest sample size used, but for this activity you will sample 25% of the students in that grade level. If your students know how to calculate 25% of the total number of students in that grade level, let them do it. If they do not, explain that 25% is one-fourth of the students in their grade level and tell them how many students that is.
    - Make a plan for collecting surveys. Ask the following questions:
        - Should they survey a set number of students from each classroom?
        - How will the students who take the survey be selected?
        - Is it a good idea to have half the students surveyed be girls and half be boys?
        - Who will survey the students?
7. Conduct the survey using the plan created in steps 5 and 6.
8. Tally and chart the results.
    - Since students have had opportunities to participate in tallying survey results in a previous activity, decide if you want to do the tallying as a class activity or to do it yourself and share the results with them.
    - Make the same decision related to creating the bar graph that shows votes for each kind of playground equipment.
    - Discuss the results.

9. Expand the review of the results by asking what other data were collected in the survey (e.g., gender, age).
    - Ask students if it would be of value to graph those results? Why or why not?
    - Optional: You may want to have students work in small groups to graph results using gender, age, or other attributes that were collected in the survey.
10. Lead a discussion (whole class for students in grades K–2, small groups for students in grades 3–5). Ask students the following questions:
    - What do you think about the results?
    - Do they represent all students at their grade level?
    - Is there a better way to think about their results?
    - Will most students be satisfied with the playground equipment that would be purchased if this survey were really used to make decisions?
    - Is this a fair way to make decisions? Why or why not?
    - Could this decision hurt anyone? How?

CULMINATING PERFORMANCE

Activity 5: What Does This Have to Do with AI?

In this culminating performance, students will explore the connection between the preceding activities and artificially intelligent apps that use machine learning algorithms to make video and music recommendations for people who use those apps.

1. Demonstrate the use of YouTube Kids or another app that uses data it collects to make decisions about what videos a student might want to watch.

> **NOTE:** The demonstration directions in the following steps are based on use of YouTube Kids. If you demonstrate a different app you will need to adjust the demonstration accordingly.

    - Ask how many students watch videos using the YouTube Kids app, or something similar.
    - If any students say they do, ask them to explain how they decide what videos or music they want to watch or listen to.
    - Open the video app you selected for this demonstration on your laptop and project it for the class to see. Point out that when you open the app, you are able to choose an age group and also indicate if you want to select a show, music, an educational video, or just want to explore.
    - Remind students that you collected information from them during Activities 3 and 4 when you pretended first to select a classroom pet and then when you pretended to choose new playground equipment. Ask:
        - What kinds of information did our surveys include (e.g., name, gender, age, kind of animal, or type of playground equipment)?

- How might that information be used to make decisions?
- What information is the app collecting as you get to where you can choose something to watch or listen to (age group and type of video or music)?

2. Make the connection between data collection and apps that make recommendations.
   - Mention that this information is being collected because the app uses **artificial intelligence** (AI) to learn what each user likes or dislikes.
   - Tell students that AI is the science, engineering, and creation of computer programs that attempt to imitate human intelligence.
   - Explain that one thing AI can do is collect data and then analyze it to find patterns, just like we collected information and looked at patterns in that information in Activities 3 and 4. Examples used to teach an AI is called **training data**. The app makes predictions or decisions about what a user might like or want to do next, based on what the user has already done (as well as what other similar users have done).
   - Click on the various categories. Ask students what they see (lists of preselected options they can choose from that are different based on the category they choose).
   - Explain that right now their choices are based on the two pieces of information they have given the app: the class age group and the type of video or music you click on.
3. Explore Search function.
   - Ask students what they think will happen if you type a word like "spider" or "egg" into the Search bar and press Enter.
   - Demonstrate searching using these two keywords.
   - Point out that the results now are organized not by type of video or music but by the search topic, with all categories mixed together.
   - Try a couple of other searches using key words the students suggest.
   - Ask them what new information the app has collected from the searches (possible areas of interest like spiders, eggs, or whatever else they searched for).
   - Explain that just as it was possible to learn more about what different groups of students in the class thought would make a good pet when age or gender were considered, every word used as a search term is teaching the app's AI more about what a particular user might want to watch or listen to. The next time that user logs on, the app will be able to recommend videos and music based on the information it was given before.
   - Remind students that in this case, AI is a computer program that collects information and then makes predictions about something a person might be interested in based on that information. But the decision about what to collect and how to collect it comes from people, and as we have learned in other activities, people often make decisions based on unconscious bias. In addition, just because an app makes a suggestion doesn't mean that the user must take it. Users are always in charge of the decisions they make.

4. Use direct instruction to help students develop an understanding of how the data are used over time to train the app.
    - Explain that the app tracks several pieces of data for each user including:
        - Which videos you choose and how much of each video you watch.
        - What search words you use and if you make selections from the results.
    - Say that all of this information is used as training data to teach the app what a user likes and doesn't like.
    - At the same time, every user's data also teaches the app what other users who are the same age might like and dislike. That information is used to make suggestions to other app users who are the same age.
    - Remind students to keep in mind that even then, their choices are always limited to what is included in the training data, such as the previous search terms provided by other users. Ask students to think about this carefully. When they first use an app like YouTube Kids, the suggested videos/music are based on very little information about them individually. Instead, the app uses information it has gathered from all users in the same age group who have used the app previously. But just as was learned in Activities 3 and 4, not all students like the same things. So, when an app makes predictions for one user based on what others like or don't like, it can be very wrong because its choices are limited to the interests of a specific group of users, even when those choices might reflect stereotypes about students in general.
5. In a whole class discussion, introduce the idea that users–and the data they provide–can change what a program has been taught about them.
    - Ask students if they think it is possible to change what a program has been taught about them. Accept all answers at this point.
    - Explain that it can be done, but it might take a little while, because the AI would need a lot of new examples to unlearn what it already has learned about you.
    - Brainstorm a list of the kinds of information the app already collected during the demonstration.
    - Ask the following questions:
        - Imagine your parents gave you permission to change your profile's age group How might that affect the videos you get to choose from? (Hint: this would make a significant change right away.)
        - Now, pretend you clicked on videos you aren't interested in watching but let them play all the way through anyway. Would that affect the program's predictions about what you might want to watch next?
        - Imagine searching for topics you really aren't interested in. Could that affect the suggestions you get for videos/music?
        - Finally, what if you were able to access the app's settings and either change permissions to access and use your data, or change the topics the app has set as preferences?
        - The answer to each of these questions is yes, using these strategies could change what an app has been taught about a user.

6. Finally, ask students to think about other apps they know about that make suggestions for users. (Possible answers include Netflix, HBO Max, Hulu)
    - Have students turn to a shoulder partner to talk about what they understand now about these AI-powered apps that they didn't know before.
    - Then have students share their thoughts with the entire class.

Activity 6: Reflect

In this activity, students should discuss the following questions to reflect on the societal impact of AI and how it makes decisions:

- What have you learned about how data are used to make predictions or decisions about what people might like?
- Does AI always make predictions or decisions that are correct? Why or why not?
- Who is really responsible for the decisions made by AI?

Extensions

Following are two ways you can expand students' exploration of how fairness and equity are impacted by the quality of data used by AI to make predictions and decisions about things people might like or want to do:

1. Give students additional practice in recognizing stereotypes and unconscious bias in training data through a learning center. For example, capture screenshots of image searches of people in specific occupations, such as nurses, farmers, stay-at-home parents, or scientists. Give copies of these screenshots to students and ask them to analyze the patterns in the features they see in each screen shot. Help them make the connection to how training data (in this example photos of people in specific occupations) can impact datasets. For example, if most training of the data for identifying nurses includes female nurses, the AI will learn that all (or most) nurses are women.
2. Extend students' thinking about the ethics and societal impact of using AI technologies through the "What AI Does Well and Does Not Do as Well" and "Training Data and Machine Learning" projects found in *Hands-on AI Projects for the Classroom: A Guide for Elementary Teachers*.

> I'm excited about this project because it integrates several activities into learning standards across the curriculum. Students could have a nuanced discussion of these ethical topics and dig into both math and language arts while learning about AI. We can think effectively because of how easily we remember patterns (like the shape of letters that we turn into words–we don't have to keep sounding out every letter forever), but not all patterns are good, and we have to spend time rethinking patterns that are untrue or unhelpful.
>
> —Charlotte Dungan, AI Program Architect, North Carolina School of Science and Mathematics

PROJECT 2
Who Is in Control?

Students discovered in Project 1: Fair's Fair that people are often unaware that they are participating in passive data collection through surveys and other activities, both on- and offline. In this project, students' attention is directed toward how their personal data may be used to influence their thinking.

> It is so incredibly important that we teach our students about the ethical implications of artificial intelligence and its impact on our society–both positively and negatively. After watching "The Social Dilemma," I really wanted to find a way to teach my young students (grades 3–6) about the ethics of AI, but in a more age-appropriate way than the documentary. This project hits the nail on the head!
>
> —Adam Brua, Technology Integrationist, Rutland City Public Schools

Project Overview

This project offers students opportunities to explore different ways people become consumers of targeted marketing based on personal and group profiles. These profiles are created by machine learning algorithms using data trails left during their online activity. One critical ethical question asked in this project is: Should we be concerned about how algorithms influence our lives?

SUBJECT

English Language Arts
Technology/Computer Science

ESTIMATED DURATION

6–7 hours

TARGET GRADES

3–7

VOCABULARY

artificial intelligence
recommender systems
dataset
data trail
machine learning algorithm
targeted marketing
training data

OBJECTIVES

At the end of this project, students will be able to:

- Define the term targeted marketing, describe its purpose, and explain how targeted marketing is used to influence decisions people make.
- Understand that artificially intelligent computer programs create profiles of individuals or groups of people who have something in common (e.g., age, grade level, or membership in a club) based on personal data gathered online and then use these profiles to predict what online information—in the form of advertisements, search results, videos, or other information—people in these groups will like or believe. This is done using something called a machine learning algorithm.
- Understand that machine learning algorithms filter online information that people see based on individual and group profiles.
- Consider the positive and negative impacts of the choices people make based on online information they receive as determined by machine learning algorithms.

STANDARDS

ISTE Standards for Students

1. Empowered Learner

d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. Digital Citizen

a. Students cultivate and manage their digital identity and reputation and are aware of the permanence of their actions in the digital world.

d. Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.

3. Knowledge Constructor

b. Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.

ISTE Computational Thinking Competencies

1. Computational Thinking

e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. **Equity Leader**
   - **b.** Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.
   - **e.** Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

AI4K12 Five Big Ideas in AI

3. **Learning**
   Computers can learn from data.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.SL. 3.1, 4.1, 5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.3.2, 4.2, 5.2: Determine the main ideas and supporting details of (grade 3), paraphrase (grade 4), or summarize (grade 5) a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

CSTA K-12 Computer Science Standards

1B-IC-18: Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

Media Literacy Standards to Counter Truth Decay

3. Understand how modern information sources and tools can limit available facts and perspectives (e.g., search engine algorithms; specialized discussion groups; selection in social media connections).
4. Identify the expertise (e.g., academic, office held, firsthand knowledge) and consider the motivations (e.g., political, financial) of the creator of an information product.
6. Analyze information for bias, deception, or manipulation.
11. Recognize the ways that media and information products might trigger emotional responses that influence attitudes or elicit specific behaviors.

Preparation

MATERIALS

- Computer(s) or tablet(s) (one per student) with internet connection for accessing web browsers (e.g., Chrome, Safari, or Microsoft Edge), specific search engines (e.g., Google, Bing, or DuckDuckGo), and other online resources
- Writing materials such as paper, pens, pencils
- Chart paper and markers for brainstorming

SUPPORTING RESOURCES FOR EDUCATORS

- Video: "**What even is an algorithm?**"
- Video: "**There's No Anonymity**"
- Article: "**A simple way to explain the Recommendation Engine in AI**"
- Article: "**DuckDuckGo vs. Google: An In-Depth Search Engine Comparison**"
- Article: "**How Google Search Works**"
- Article: "**Media Literacy Standards to Counter Truth Decay**"
- Article: "**So Many Choices**"
- Activity: "**Privacy in the Information Age**"

ADVANCED PREPARATION

- Familiarize yourself with the topics addressed in this project by viewing the video, "What Even Is an Algorithm?" (which you may decide to show to the class) and reading the articles listed under Supporting Resources for Educators.
- Study the activities and decide ahead of time how you want to approach each of them.

Instructions

GETTING STARTED

Activity 1: Online Information and You

In this activity, students consider the kinds of online information they encounter in their daily lives, such as advertisements, search results, and more. They are asked to consider why someone might want to be very scientific about who receives the information they are distributing online and why.

1. Engage students' interest by referencing previous online experiences they may have had.
   - Ask students if they have experienced searching for something online—perhaps a game or an article of clothing—and later on noticed many ads for that same thing on websites they visit. Or, have they watched a video on a streaming site and then had a similar video automatically start to play as soon as the first one they watched ended?
   - Ask if they know why that happens. Guide the conversation to the concept that the appearance of related ads or videos is not accidental—that these are examples of something called **targeted marketing**.
   - Tell students that for this activity, your definition of targeted marketing is the process of figuring out which individuals or groups of people are most likely to respond positively to specific advertisements, recommendations, or other information and then making sure those people get that information. Why would a company or organization take the time to know who their customers are? Is the purpose to help customers or to help the company or organization?
   - Ask students to spend a few moments individually thinking about their answer to the following questions and then to write down a list of their ideas.
     - Why would a company or group take the time to know who their customers are?
     - Are companies curious about their customers to help the customers or to help the company or group?
   - Lead a class discussion of their ideas. Record some of their main ideas on the whiteboard or a sheet of chart paper. Tell students that the goal of targeted marketing is to influence people as they decide if they should buy a product or service, watch a video, or click on a suggested link.
2. Tell students they are going to spend a little time focusing on one form of targeted marketing: advertisements.
   - Form groups of 3–4 students and give them a few minutes to share their ideas about the purpose of advertisements with one another. Ask each group to choose the two most important ideas from their discussions and share those with the entire class. (By the end of this step, ensure students understand that advertisements are carefully designed to encourage people of all ages to buy products or services from someone.)
   - Through direct instruction, explain that advertisements have been around for hundreds, even thousands of years. Over time, ways of advertising have changed to reflect how people shared important information with one another. For example, a couple thousand years ago people shared information including ads by painting messages on walls or by etching messages on steel plates placed in places where lots of people would see them. This information could be shared with small groups of people, but everyone got the same message. Members of these groups might be interested in what was being advertised, but maybe they were not.
   - Still in their small groups, students talk about where they most often see or hear online advertisements. Ask them to respond to the following questions:
     - Where do they usually see online advertisements?

- How are these ads presented? Are they text, video, audio?
- Extend the conversation by asking students to talk with one another about how ads make them feel and why they think that might be.
- Ask the small groups to share their ideas about online advertisements. Record common ideas shared by the students on a new sheet of chart paper.

- Point out to students that they have just thought about where they see ads and how those ads make them feel. Remind them that until recently most ads were seen by a limited number of people, but that things are different today because it's possible that advertisements, especially those that are online will be seen by hundreds of thousands of people from around the world.
- Ask students if they knew that people who see advertising on a laptop, tablet, phone, or other device are probably seeing ads chosen especially for them? Explain that they and a friend might decide to stream the same video online but see a completely different ad at the beginning of that video. Ask if they have any idea why that happens?
- Direct students to pay attention to advertisements they see or hear the rest of the day. Specifically ask them to notice where and when they see them. Do they pay attention to the ads or ignore them? How do they feel when they see or hear an ad?
- Ask students to be prepared to share their observations during the next class day.

TAKE A CLOSER LOOK

Activity 2: Exploring How Machine Learning Algorithms Make Predictions About Us Using Targeted Marketing

In this activity, students are introduced to basic concepts related to targeted distribution of ads and other information based on use of machine learning algorithms and data. In Activity 1 students were asked to think about targeted marketing, and advertisements in particular: what they are, their purpose, and where or when they usually see or hear them. In this activity, students learn a little more about how advertising has been distributed in the past and then look at how AI and machine learning algorithms are used today to ensure that online information, including advertisements, is seen and heard by the people most likely to be interested in that specific information.

1. Introduce this activity by explaining the following concepts:
   - Explain to students that throughout much of history, people had limited access to any kind of information. As technologies have developed—the printing press, for example—the ability to share information with people expanded greatly. Before information was mass printed using presses, very few people could read. Partly that was because few people had opportunities to be educated, but it was also because all books at that time had to be copied by hand, making them fairly rare.
   - Thanks to the printing press it was possible to make copies of books and other writings easily and cheaply. Just as the printing press made it easier to create and share books and other written information, it also made it easier to create advertisements to let people know about products and services they could

purchase. The ability to share this information with larger groups of people than had been possible before helped local businesses grow.

- But just being able to print and distribute information did not mean that the right people always saw it. Maybe someone who wanted an advertised product or service or other information would come across it, but maybe not. By the 1700s and 1800s in the United States, businesspeople tried to get information out to possible customers using newspaper ads, billboards, and postcards. When radio and television were invented in the first half of the twentieth century, and people were able to listen to or watch programs, advertisements became an important part of programming. But it was difficult to know if the information was getting to the right people.
- The invention of the internet changed that, making it possible to reach thousands of people around the world with ads and other information and to program computers using **artificial intelligence** and something called **machine learning algorithms**. Artificial intelligence is the science, engineering, and creation of computer programs that can imitate human intelligence. A machine learning algorithm is a process or set of rules used by a computer to find patterns in data. These processes enable computer programs to use data to recognize the people most likely to be interested in a product, service, or other information, and then make sure they see or hear it.

2. Make the connection between information found on line and it being directed to a specific audience by exploring the following concepts:
   - Explain that for a machine learning algorithm to be effective, it needs a tremendous amount of accurate, relevant training data.
     - Training data consists of examples used to teach a machine learning model. How is **training data** collected? One way is by tracking what people do when they are online.
     - Ask students to work in pairs or trios to brainstorm a list of the apps, websites, and other tools they use online. Examples might include: search engines, streaming sites for video or music, games, etc.
     - Mention that every time anyone goes online, they leave a **data trail**. A data trail is a collection of personal information tracked through a person's actions online, such as what sites or apps they used, for how long, what they did there, or who they are (if they logged into an account). All of this information is stored and used to tell companies what you as an individual do online, and is also added to **datasets** that store what people like you do—for example, elementary students in grades 3–5, kids who live in your state, or kids who are 8 to 10 years old who like to play games. Without realizing it, people are adding to datasets every time they go online.
     - Ask students to talk with their partners or trios about what kind of data trail they might be leaving behind. Then create a class mind map organizing what might be in these data trails by category.
     - Have students share their answers with the whole class, and create a class mind map organizing what might be in these data trails by category.
   - Tell students that machine learning algorithms are programmed to find patterns in collected data. For example, the algorithm may determine that more fourth graders spend time playing online game A than

playing online game B or that fewer girls than boys click on videos about poisonous snakes. In these cases, the algorithm might predict that all fourth graders prefer game A or that all girls do not like videos about poisonous snakes, even though neither prediction is true. As a result, an online game site might not show a link to game B to users identified as fourth graders, or a video streaming site might not show users who identified as girls any links to videos about poisonous snakes.

- Ask students to consider the pros and cons of targeted advertising that uses machine learning algorithms like the ones just described. One the one hand, most people would rather see a majority of ads that tell them about products that they would likely be interested in instead of seeing ads for things they wouldn't like. On the other hand, this means people might not know that there are choices they could be making, if they knew they existed. Here are a few questions to reflect on in their pairs or trios:
  - Should people's choices be directed or limited by a computer program?
  - Are these ads helpful when it points people to products, news, or events they want to know about?
  - How might it be harmful to people if targeted ads keep them from hearing about important products, news, or events because the algorithm doesn't think they will be interested?
- Conclude this activity with a whole-class debriefing discussion.

Activity 3: Exploring How Machine Learning Algorithms Make Predictions about Us Using Recommender Systems

In this activity, students explore how predictions made by recommender systems using a machine learning algorithm may impact people's decisions.

1. Introduce this activity by explaining the following concepts:
   - Another application of machine learning algorithms is something called a **recommender system**.
     - Explain that this is a computer program that makes suggestions about products, services, or other information that users might like based upon data collected about the individual person, or about groups of people who are similar to the person getting the recommendation. Again, the idea is to make it easier for someone to find what they want, but based on its programming, the algorithm also limits a person's choices. Familiar examples of recommender systems include those used by Netflix, YouTube, Spotify, Disney+, and even online stores.
     - Ask students if they or their parents use video streaming services or shop online. If so, do they pay attention to the suggestions made to them? Why or why not?
   - Demonstrate this technology by projecting your laptop screen to illustrate for students the points you are making (or, instead of a live display, walk through the three examples described below and take screenshots to share those images with students instead of a live display). Following are three examples of what you might show (try these out yourself prior to sharing with students to ensure suitability):
     - **Netflix or similar sites featuring series and movies.** Sites like this make suggestions about what videos subscribers might want to view next. Streaming accounts allow users to create a limited

number of profiles for individual viewers. Each profile typically offers a category called Trending Now, or something similar. The phrase Trending Now might imply that this is what everyone using that site is watching now. However, when viewing Trending Now suggestions in different profiles, even in the same account, are they the same? Why do multiple profiles on the same streaming account have such different suggestions for what to watch next? Can students guess anything about the person who uses each profile based on the recommendations? What are they basing those guesses on?

- **YouTube or similar sites featuring short videos.** Begin a search using keywords like grade 4 math. How well do the initial suggestions relate to various grade 4 math concepts? Select one video.

  Pause the video and look at the suggestions to the right. Are they all related to math? If not, what happens if you click on a non-math related title? Now what kinds of recommendations do they see?

  The keywords for the original search remain, but the results have nothing to do with math. How does a search for videos that help with a school topic get so quickly off the track?

- **Any online bookstore.** Tell students that a friend said you might want to read a book called *The Lemonade War*. When you went online to order it, you were given a list of seven other books you might want to purchase. Why does a search for one specific book title lead to a suggested reading list? How do they think these recommendations are being made?

2. Have students meet in their pairs or trios to talk about what they think happened. Have them discuss the following questions:
   - Are these examples of machine learning algorithms making decisions for people?
   - What are the benefits of seeing these recommendations?
   - What are the drawbacks of relying on recommendations?
   - Based on what they have seen, are these recommendations always accurate? Why or why not?
3. Ask students to choose one of the three examples and develop an explanation of how they think the recommendations were made. Ask them to address the following questions in their pairs or trios:
   - What data were collected and used?
   - How accurate were the predictions made?
   - Were the predictions this helpful? Why or why not?
4. Make the connection to ethical use of artificial intelligence by sharing the following concepts with students:
   - In addition to the pros and cons just discussed, some people are concerned that recommender systems do such a great job at giving people what they want that it can lead to wasted time or addiction to our digital devices.
   - Ask students: Have you had the experience of watching one video or episode of a show, but then realized that because the service kept autoplaying things that you liked, you had watched many videos or shows without choosing them or thinking about whether you wanted to keep watching? Give students a few minutes to discuss this question.

- Point out to students that the algorithms that select video and show recommendations for individual users are designed to make the company money by recommending relevant content. It might keep users watching as long as possible to generate revenue on advertising sales. Alternatively, the company might sell more subscriptions if the algorithm recommends additional videos or shows that customers want to see. The more often they give users media that will keep their attention, the longer they'll use the site or the app, and the more money the service makes.
- Explain that the sites do not judge the quality of the content of the videos, just whether or not people continue watching them. Ask students to discuss the following questions in their pairs or trios:
  - What might be the effect of keeping people watching for long periods of time without thinking about it?
  - What might be the impact of showing people videos that will keep their attention without the algorithm considering whether the content of the videos will be good or bad for the viewer?

Activity 4: Exploring How Machine Learning Algorithms Make Predictions about Us Using Search Engines

In this activity, students explore how predictions made by search engines using a machine learning algorithm may impact people's beliefs and decisions.

1. Introduce this activity by asking students to identify what they have learned about how machine learning algorithms can impact the information they see when they are online.
   - If they need prompting, remind them about the discussions the class had during Activities 2 and 3.
   - Mention to students that even when they don't sign in to an account, there are ways to track the device being used online and gather information about websites visited, searches conducted, etc. Tell students that although companies often say that machine learning algorithms are intended to make it easier for people to find information that will be of interest to them, these algorithms can also limit the choices people have by including links just to what the algorithm predicts the person will want.
2. Tell students that they are going to experiment using two different search engines to see how results vary from one person to another. The search engines they will use are Google and DuckDuckGo. Each student should have an internet-connected device and a partner.

   > **NOTE:** Ideally, each student needs to have an internet connected device and a partner for this activity. If that is not possible, students can do this activity in their pairs or trios or the teacher can demonstrate the activity to the entire class using a laptop and projection device.

   - Ask students what they know about how search engines work. Allow them to share their ideas.
   - Explain that search engines are designed to help people find online resources that will be most useful for them out of the millions of possible choices. Most search engines do this by using machine learning algorithms that make predictions based on the search terms you use, where the computer you are using is located, the privacy and other settings on the device you are using, and even personal information about you if you are using a search engine within a web browser you can log into, such as Google Chrome.

- Begin the activity by having all students open the web browser they normally use at school. What search engine do they use by default? (You may need to help identify the search engine they are using, most likely Google, Bing, or Yahoo—but it could be something else.) Write the following list on the whiteboard or a piece of chart paper:
  - Bicycles
  - Online games for kids
  - UFOs
- Ask the student duos to choose one of these topics to search for, using the default search engine. Or, allow them to choose a topic of their own, as long as they both agree to use the same topic. Students should type in the topic they chose on each of their own devices and press Enter. Ask them to compare the results they get with their partner. What kinds of resources do they see (e.g., images, websites, files, ads). Are the lists identical on each device or not?
- Now ask them to open a new browser window and navigate to **DuckDuckGo**. Explain that DuckDuckGo does not use machine learning algorithms to decide which results individual users will see because it does not collect tracking data to create profiles for individuals or groups. Ask students to conduct another search using the same topic. What results do they get this time? Are they the same as their partners' results? Are they the same as their first search results? Why do they think that is?

3. After providing a little time for students to try several side-by-side searches, lead a whole-class discussion during which students reflect on this experience. How is it similar to results they got in Activities 2 and 3? How is it different?

CULMINATING PERFORMANCES

Activity 5: Using Data Trails to Profile Someone

In this culminating performance, students will create a data profile for themselves based on the kinds of data trails people regularly leave behind when they are online.

1. Tell students they are going to use what they have learned about data trails to create a data profile for themselves using a format you will share with them. Be sure to tell students not to include their names because after they turn in their profiles, the papers will be shuffled and each student will be given someone else's profile to analyze.
2. Give each student a piece of 8.5" x 11" blank, unlined paper. Ask them to fold the paper in half so it makes a rectangle about 8.5" x 5.5" and then fold that in half again to make a rectangle about 4.25" x 5.5." Unfold the paper and label the sections created by the creases as follows:
   - Top left box: Two keywords I have used for online searches
   - Top right box: Three websites I have visited (name of each site)
   - Bottom left box: Three online videos I have watched
   - Bottom right box: Two online games I play regularly

Now have students take a few minutes to add the information needed in each box. Collect the completed profiles, mix them up and give a profile to each student (not their own).

3. Tell students they are going to use these bits of information to try to learn about the person who created the profile they now have. On a separate sheet of lined paper they should write the following:
   - Describe the kind of person they think would have created this profile, such as athletic, musical, outgoing, or studious. Why?
   - Design an ad for a product they think this person would like.
4. Each student briefly shares with the class the description they were assigned, the ad they created, and what bits of information they used from the profile to select the product for the ad. The creator of the profile should then claim it and reveal if they would or would not like the product in the ad created for their profile.
5. Make a table with two columns on the board. Label one "Would Buy" and one "Would Not Buy" and keep a tally as students state their preferences. At the end of this activity ask the class to use the tally to help them decide how effective the profile was in identifying what each person might like. If there were more incorrect than correct guesses, what additional information could be collected to improve the results? If there were more correct than incorrect guesses, what bits of information were most helpful?
6. Help students conclude that bits of information about someone can be gathered, analyzed, and then used to make predictions about something that person might like or dislike. While in this case each person had access to only a small amount of data about each user, AI that uses machine learning algorithms can quickly gather and analyze massive amounts of data about us. With that much data, the machine learning algorithm can have very high accuracy in proposing targeted ads, recommender systems, and search engine results that will get and keep the user's attention.

Activity 6: Reflect

In this activity, students should discuss the following questions to reflect on the societal impact of targeted marketing.

Ask students to think about the following questions and then write a reflection. When finished, allow volunteers to share some of their thoughts.

- Should we be concerned about the influence of machine learning algorithms on our lives? Why or why not?
- Whose best interests are served when we allow ourselves to be influenced in this way?
- How might these algorithms impact schoolwork or activities at home?
- What strategies can we use to make sure that the impact algorithms might have on decisions we make is a good one?
- What does this have to do with data privacy, and why should we care?

Extensions

Following are three ways to expand students' exploration of ways people may be influenced by targeted marketing based on personal and group profiles.

1. Use the data profiles students created for the Culminating Activity to extend the conversation. Ask students to retrieve their own profiles. Challenge them to think about the kinds of information that might be discovered about them based on their own online activity by writing brief responses to the following questions:
   - What were some similarities and differences between the profiles that were shared during the culminating activity?
   - Which of the data pieces helped identify individual classmates?
   - Were there ways to combine the information to help guess who created the profile?
   - How could you be more mindful of your data trail?
   - Is it your responsibility to monitor your data trail? Why?
2. In the Culminating Activity, students provided information about online activities they engage in which was then used to create a profile about them and then to make a prediction about who they are and a product they might like. Here is another approach to helping students see how a data trail can lead to personally identifiable profiles. Try this modified version of an activity originally called Privacy in the Information Age.

   > **NOTE:** To model protecting their own personally identifiable information, ask students to each use a fake name and birth date for this activity.

   - As a class, create a three-column table on the board. Label the first column Fake Name, the second column Birth Dates (month/day/year), and the third column Favorite Food. Ask students to make up a name and birthdate and add this information to a row in the table on the board. Be sure to tell them that a person's name and birth date are considered personally identifiable information.
   - Give each student a slip of paper and ask them to write down the fake birthdate they added to the list on the board and a favorite food. Collect the paper slips in a small box or other container.
   - Ask a student to draw one slip out of the container and read the birthdate and food out loud. Ask the following questions:
     - Can they guess which fake name is associated with the favorite food written on the slip of paper simply by comparing the birth date written on the paper with the list of birthdays on the board? Why or why not?
     - What would happen if they knew just the birth month and year?
     - What would happen if they knew just the year?
     - What would happen if they did not have the birth date at all?

- Add the favorite food to the table in the row that students identify as being the best match with the birth date and fake name already there. Repeat this process several times.
- Ask the students whose slips were drawn and recorded to confirm if the favorite food was listed in the proper row of the table.
- Ask the class to respond to the following questions:
  - Which level of information—no birth date, year only, month and year only, full birth date—made it easiest to correctly guess the fake name associated with the birth date? Which level of information—no birth date, year only, month and year only, full birth date—made it most difficult to correctly guess the fake name associated with the birth date, thus offering the most privacy? Why do they think that is? What does this tell them about personally identifiable information?
  - Would it have been easier to assign the favorite food to a row if students had also been asked to write on the slip of paper the first and last initials for the fake name they added to the table? Why or why not? Help students understand that initials and birthdate would have provided two data points to compare, making it much easier to identify the proper row for each food. But that would have meant giving up more personal information. Is that something that they would want to do? Why or why not?
  - Would there be a way to figure out where to record each favorite food without giving up any personal information? How?

3. Explain that the more bits of personal information collected, the more likely it is that a personally identifiable profile can be created. For example, what if each person's address was known, or the name of their school? Should companies be permitted to gather data and create profiles that actually identify individual people? Why or why not?
4. Extend students' thinking about machine learning algorithms and their impact by teaching the "Training Data and Machine Learning" project found in *Hands-on AI Projects for the Classroom: A Guide for Elementary Teachers*

> This project introduces targeted marketing as a concept and does so in a way that is approachable for elementary and middle school students. I also appreciate the connection to media literacy and thinking about our digital presence (even beyond creating profiles on social media or other websites). I'm also excited about the culminating activity, because I think it is a strong active learning experience that clearly teaches students about data trails and how machine learning algorithms can influence our digital lives. One suggestion I would give to teachers who use this project is to consider using examples that are most relevant to their students, which will increase motivation in learning about the topic.
>
> —Caitlin McLemore, Educational Consultant, Blank Crayon

PROJECT 3

The Trade-offs of AI Technology

Artificial intelligence technologies are becoming more prevalent across different fields and industries, transforming the way everyday tasks are completed and, in many cases, doing them faster and with fewer errors than humans. Yet, the use of AI technologies doesn't always go as planned. Sometimes it leads to unintended consequences; biases; and loss of jobs, privacy, or freedoms.

> The more I think about it, all of technology has been a series of trade-offs. A sword is better than a pointy stick, but you have to be stronger to lift it and it requires forging, sharpening, cleaning, etc. Too often we just see the benefit, but rarely stop to think of what we are either giving up or passing over when we make those choices, especially in technology fields. Making that a very personal and deliberate choice makes a lot of these AI discussions much more thoughtful and meaningful.
>
> —Mark Gerl, Technology Teacher, The Galloway School

Project Overview

In this project, students explore the opportunities and shortcomings of a variety of AI technologies. In the process, they consider the stakeholders affected by AI technologies, examine the trade-offs involved in AI design and use, and consider ways that they can personally impact the ethical use of AI technologies in their own life and in the lives of others.

SUBJECT

Technology, Computer Science, English Language Arts, Civics, Government

ESTIMATED DURATION

3–8 hours

TARGET GRADES

6–12

VOCABULARY

active data collection
artificial intelligence
call to action
ethical
ethics
model card
passive data collection
stakeholder
trade-off

OBJECTIVES

At the end of this project, students will be able to:

- Understand that all decisions, including those made by artificial intelligence, involve trade-offs.
- Describe the pros and cons of using or implementing various AI technologies.
- Make more informed decisions about the data they share and the AI technologies they use.
- Articulate a personal position related to the use of AI technologies.

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
2. **Digital Citizen**
   - d. Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.
3. **Knowledge Constructor**
   - d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
4. **Innovative Designer**
   - d. Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.
6. **Creative Communicator**
   - c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.
   - d. Students publish or present content that customizes the message and medium for their intended audiences.
7. **Global Collaborator**
   - c. Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.
2. **Equity Leader**
   - e. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.
4. **Creativity & Design**
   - c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.
2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.
4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

CSTA K–12 Computer Science Standards

2-IC-20: Compare trade-offs associated with computing technologies that affect people's everyday activities and career options.

2-IC-23: Describe trade-offs between allowing information to be public and keeping information private and secure.

3A-IC-24: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.

3A-IC-29: Explain the privacy concerns related to the collection and generation of data through automated processes that may not be evident to users.

3B-AP-08: Describe how artificial intelligence drives many software and physical systems.

3B-IC-28: Debate laws and regulations that impact the development and use of software.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.W.6.1 through 11-12.1: Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-LITERACY.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

CCSS.ELA-LITERACY.WHST.9-10.7/11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online
- Writing materials such as paper, pens, pencils
- Online articles, tools, and resources listed below
- Optional: A digital copy of The Trade-offs of AI Technology: Activity 3 **graphic organizer** for each student or student group
- Optional: Headphones for watching videos during Activity 3

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Ethical Concerns of AI**"
- Article: "**Top 9 ethical issues in Artificial Intelligence**"
- Article: "**1st Party Data, 2nd Party Data, 3rd Party Data: What Does It All Mean?**"
- Video: "**There's No Anonymity**"
- Website: **DigCitCommit**
- Book: ***Blown to Bits: Your Life, Liberty, and Happiness after the Digital Explosion*** by Hal Abelson, Ken Leedon, and Harry Lewis

ADVANCED PREPARATION

This project can be facilitated in several different ways, depending on the time you have available in your course. Before beginning the project, determine which of the following implementations you will likely use.

- If your class time is limited to 3–4 hours of project time, focus your attention on Activities 1–3, use a jigsaw instructional strategy for Activity 3, and have students conclude the project with their Activity 3 class presentations and discussion.
- If you have 4–8 hours of project time, complete the provided project activities as written. Use the time you have allotted to determine the depth to which students will work on their group presentations in Activity 3 or culminating performance options A or B.
- If you have 8 hours or more, this project could provide a framework for a full unit on AI and ethics. For Activity 3, instead of using a jigsaw instructional strategy, have all students explore each of the seven categories of AI technologies listed. For the culminating performance, students can complete options A and B, and even work as individuals, in groups, or as a class to develop presentations about their calls to action to share what they have learned about AI, ethics, and trade-offs with an audience of students, educators, parents, or the community.
- Alternatively, this project can also be used cross-curricularly in a combination of technology, computer science, English Language Arts, civics, and government classes. For example, a middle school technology teacher might teach Activities 1–3, while the English Language Arts or civics teacher subsequently teaches Activities 4–6.

There are many links to media resources shared throughout this project, including videos to show to the whole class and resources for students to explore independently or in small groups. Prior to class, review the materials and decide how you will distribute them to your students. For example, if you choose to use The Trade-offs of AI Technology: Activity 3 **graphic organizer**, it is provided in Google Doc format. As you prepare for this activity, make your own editable copy, edit or update the questions or resources if desired, and distribute to your students in your preferred format.

Instructions

GETTING STARTED

Activity 1: Artificial Intelligence and Trade-Offs

In this activity, students will develop contextual knowledge around artificial intelligence, ethics, and the idea of trade-offs.

1. Introduce this project with a definition and description of **artificial intelligence**.
    - According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007).

A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

2. Have students watch the video "**What Is Artificial Intelligence? #1**"
3. Say, "In the video, you heard about many different applications of AI technologies. Jabril mentioned that some people are excited about the impact of AI, while others might be afraid of it. As with any new technology, there are **trade-offs**—pros, and cons of using it. A trade-off is a balance or compromise between two or more desirable, but competing or incompatible options."
4. To help reinforce the concept of trade-offs, play a "would you rather" style game with your students. For each of the trade-off examples below (or others you create based on your students' interests), read the prompt aloud and then have the students vote for their choices. Briefly discuss the consequences of choosing either action in relation to the other before moving on to the next scenario.

   Trade-off examples:

   - You have a 20-minute ride home on the school bus. Do you read a book or play a video game?
   - You accidentally sleep through your alarm and wake up right before it's time to go to school. Do you take time to do your hair before leaving the house even if it means being late, or leave it as it is to get to school on time?
   - On Friday night, your family is holding a family dinner to celebrate a parent's birthday, but your friends want you to go with them to a school event. What would you do?
   - You have only two hours of free time on Wednesday afternoon. Do you finish the two hours of homework you need to do for school the next day or hang out with your friends at the local coffee shop?
   - You are at a theme park and there are two rides you've been really wanting to try: a roller coaster and a water ride, but the lines are so long that you can only ride one before the park closes. Which would you pick?
   - It's Saturday night and you are hanging out at home. Do you stay up late catching up on a television series everyone else has been watching or go to bed early to get a full night's sleep?
   - Your teacher is giving a review for a big test coming up, but you feel your phone buzzing repeatedly in your pocket. Do you ignore it to focus on the review, or check your phone and risk missing something important?
5. Conclude this activity by framing trade-off decisions in the context of ethics, including the following key points:

   - You probably noticed from this activity that we don't always all agree on what the best decision is in any given situation. Each of us made our choices based on our personal priorities and value systems at the time. Those values are determined by our experiences, cultures, backgrounds, interests, and other factors.

- **Ethics** is the study of the moral principles and systems that govern a person's behavior. It is the study of the systems people use to determine what is right and wrong. When people say that something is the **ethical** thing to do, they typically mean that they believe it is the morally right thing to do.
- As with the decisions we just explored, various metrics or values might be used to determine the ethical impact of an AI technology, such as whether it is legal, fair, beneficial, or harmful.
- In this project, we will explore various AI technologies, examine the trade-offs involved in their design and use, and consider ways that you can personally impact the ethical use of AI technologies.

TAKE A CLOSER LOOK

Activity 2: AI Data Collection and Applications

In this activity, students think about the trade-off of sharing data in return for the benefits or conveniences they receive from the AI-powered technologies people use in their daily lives. Then, they consider the potential risks and unintended consequences of sharing that data.

1. Introduce this small group activity with the following:
   - Say, "In the video we watched earlier, we saw that—just as with a human baby—an AI that uses machine learning needs a lot of data in order to learn. It also needs data from users or its environment in order to apply what it has learned, communicate, generate new data, predict outcomes, or make decisions. The better the dataset an AI has, the better job it will do at performing tasks. As an individual or society, we have decided to give up some of our privacy or freedom in return for the benefits that AI technologies provide, such as convenience, personalization, or automation. This is an example of a trade-off.
   - Have students watch the TED Talk video "**Your social media "likes" expose more than you think**" by Jennifer Golbeck.
   - Say, "As you saw from this video, there are good reasons for us to consider this trade-off more closely. Whenever there are data being collected, there are also data use and privacy concerns that should be taken into consideration."
   - Say, "In the book ***Blown to Bits: Your Life, Liberty, and Happiness after the Digital Explosion*** by Hal Abelson, Ken Leedon, and Harry Lewis, the authors describe two types of data collected by technologies: footprints and fingerprints.
     - Footprints—sometimes referred to as **active data collection**—are data you know you are leaving behind and may expect to be seen or used by others. For example, if you create a new account on a website, you might give them your name, email, location, or birthday.
     - Fingerprints—sometimes referred to **passive data collection**—are data that you probably don't think about or expect to leave behind, but are being collected or tracked by the application. For example, tracking what links you click on, whose profiles you view, or even a video you didn't select, but didn't stop from autoplaying.

2. For this activity, have students work in groups of three to four to consider each of the AI-powered technology tools listed below and name what data are being collected as footprints, what data are being collected as fingerprints, and what the user gets out of sharing that data. Go over the first one together as a class, then assign each group two or three technologies from the list. After students have 10–15 minutes to brainstorm and write down their ideas in their groups, discuss each technology as a whole class. Record the students' answers on a whiteboard or in a digital table. To support your facilitation of this activity, possible answers for each technology can be found in the following table.

Technology	Footprints / Active Data Collection	Fingerprints / Passive Data Collection	User Benefit
Social Media Platform (e.g., Facebook, Instagram, or TikTok)	Likes, posts, friends/followers, tagged locations, photos, videos, messages, user tags, hashtags used, which groups you belong to, content of private messages, answers about favorites in personality quizzes	Profiles you view, ads you view, links you click on, amount of time spent in the app, what time of day you use the app, where you use the app.	Connecting with friends, good feelings from people liking your content, discovering new things
Search Engines/ Web Browsing	Search history of websites visited	Ads you view or click, links you click, time spent browsing, your physical location, your language, location where the search was made, type of device used while searching	Discovering new things; access to sites you like; personalized search results; targeted ads or product recommendations based on your predicted age, gender, interests, or location
Music and Video Apps (e.g., Spotify or YouTube)	What you 'like,' which accounts you follow or subscribe to, playlist contents, listening or viewing history	How many times you play a particular artist, song, or video; genres you prefer; topics or tags you prefer; what time of day you listen or watch; how long you listen or watch	Enjoying your favorite songs and videos; discovering new media; easily organizing your entire music library in one place; saving and sharing playlists; sharing media with friends
GPS/Map Apps	Locations you are trying to get to, locations you search, your current location	Where you live, your routine, frequently visited locations, how fast you are driving, location-based interests (food, entertainment, etc.), when you arrive at and leave locations, who you are with (from having location data from you and whomever you're with)	Easily getting to where you are going, getting real-time information about traffic

Technology	Footprints / Active Data Collection	Fingerprints / Passive Data Collection	User Benefit
Adaptive Educational Apps (e.g., Khan Academy)	Name, teacher, school, grade, which lessons you are working on, your answers to practice problems, your performance in different school subjects, what classes you are taking	How long it takes for you to master a topic	Lessons to help you learn, information about mastery and progress, moving through material as soon as a topic is learned instead of completing all the questions
Online Shopping	What you buy, what you save for later, your birthday (for promotions)	What you look at, what you have in your cart, your or your parents' credit card information, your address, how much time you spend on their site or app	Home delivery, convenience, personalized recommendations
SMART home devices (e.g., Ring doorbells, SMART thermostats, Echo, or Google Home)	Who is at your door; what commands or prompts you give it; what temperature you prefer	When you come or go from your home; what you talk about in the privacy of your own home	Convenience, home security, energy efficiency
Wearable Technologies (e.g., Apple Watch, Fitbit, sleep trackers, smart eyewear, smart medical devices)	Steps in a day, heartrate, glucose levels, REM cycles	Sensor fusion data like heart BPM while at work (heart rate monitor + GPS)	Real-time access to health data, convenience of heads-up displays.

3. Extend the students' thinking about the data they share online by considering possible risks or unintended consequences of sharing the data they listed.
   - Say, "When we share data online, we don't always know if, how, or why any of the data that we shared—as footprints or fingerprints—are being used by that computer program or that company—or even if it's being sold to a government or a third party to be used for a different purpose entirely. Sometimes we share what we think is harmless information, but on its own or when combined with other information, it might lead to unintended consequences or uses."
   - Project the infographic "**What Information Are You Driving Around?**" for the class to see. Read through the information that each of the bumper stickers reveals and the potential unintended ways that people might interpret, use, or misuse that data.
   - Review the footprints and fingerprints that your students listed about the technologies in the table above, or others that they think of. Ask, "In addition to using data to provide the user benefits you listed before, how else might people, companies, or the government use or misuse the data you said each of these technologies collected? What might they be able to know or do when they aggregate or combine data shared across these apps to create a digital profile of you? What might happen if they give or sell this data

to another company or the government?" For example, when students post their photos and a list of their favorite things, someone might use that information to guess their passwords, figure out their security question answers, or impersonate them. Or a company might evaluate the medical or mental health of its users based on their behaviors or the topics of the media they consume.

- Tell students that terms and conditions are one way of knowing how an app or company might use their data, and whether the app or company is saving, deleting, sharing, or even selling their data. Ask students whether they ever read the terms and conditions of apps they download. Discuss why or why not, as well as the benefits of being selective about which applications they use and what data they share.
- Conclude the activity by revealing that trade-offs exist in the design and use of all AI technologies. While you and your students were able to name many pros and user benefits for each of the technologies, there are also potential cons and unintended negative consequences of using these same technologies. When we choose to use an AI technology, we make a decision about the related trade-offs, such as having the convenience of using a map app, but giving up our privacy about where we are and where we go.

Activity 3: The Good, the Bad, and the Trade-Offs

In the last activity, students explored the trade-offs between sharing personal data and the benefits of using AI tools. In this activity, students will explore ways that AI is currently being used; the impact each of these uses may have on people, society, or the environment; and the trade-offs these technologies represent.

1. Introduce this activity with the following key concepts:
   - In the last activity, you thought about the trade-offs between sharing personal data and benefiting from using AI tools in your daily life. Now, let's think about other AI applications and some ways that AI might impact not only the user, but also society and the environment.
   - One way of measuring the ethical impact of AI is to determine whether it aligns with the social good. **Social good** is typically thought of as something that benefits the largest number of people in the largest possible way. In other words, something that isn't just good for one person or a small group of people, but that is good for the community or society as a whole. AI holds a lot of potential for effecting social good via applications that solve humanitarian, social, and environmental problems around the world.
   - As we considered in the last activity, the impact of using an AI technology can be positive, negative, or some combination of both. Those who have an interest in, who can affect, or who are affected by an AI technology are called **stakeholders**. Stakeholders include not only the users, but also the developers, salespeople, owners of the company, the environment, the government, or anyone else who is impacted by its use. And sometimes what is positive for one group of stakeholders might be negative for another.
2. Using a **jigsaw instructional strategy**, assign one or more of the categories of AI technologies in the table below to each individual or small group. Using the provided graphic organizer or another method of your choice, have students research their assigned technology using the questions and resources provided, and record their findings. Once students have completed their research, have them report their findings to the whole class. Ideally, students will take notes during other students' presentations as well, so that they ultimately develop a rich understanding of how various AI technologies are used and affect various stakeholders.

Note: The provided **The Trade-offs of AI Technology: Activity 3 graphic organizer** is in Google Doc format. As you prepare for this activity, make your own editable copy, edit or update the questions or resources if desired, and distribute to your students in your preferred format.

Questions for students to answer:

- What is the purpose of this type of technology? Give specific examples.
- What do you know about how this technology works?
- What data are being collected about the user?
- Who are the stakeholders of this technology (i.e., who are the users, the creators, and others affected by it)?
- Which stakeholders benefit from this technology, and how?
- Which stakeholders might be harmed by this technology, and how?
- In addition to the purpose you described, how else might this technology or this data be used for good?
- How else might this technology or this data be misused?
- How would you describe the trade-offs people must accept to use this technology? (Ex: People get _____ by giving up _____.)

Select any or all of the following categories and resources, or provide additional categories and resources based on current events and relevant student interests. Note that these categories are not comprehensive and sometimes overlap, but should provide a variety of entry points to connect with students cultures, experiences, and interests.

CATEGORIES OF AI TECHNOLOGIES

Category	Learn	Explore	Think
AI Chatbots and Companions A chatbot is a software program that simulates conversation with a human. Chatbots come in the form of virtual assistants, conversational agents, companions, and even AI social media influencers.	Video: "**What are Chatbots?**" Video: "**Google Duplex**" Video: "**This robotic therapy seal is revolutionizing elderly care**" Article: "**Why Are Brands Using CGI Influencers to Promote Skin Care and Fashion?**" Article: "**What future for humanoid robots?**"	**ALICE:** An award-winning conversational agent.	Are there ways that an AI chatbot or companion should or should not be used (e.g., for friendship, as a romantic partner, or posing as a human customer service agent)? Why? What are the ethical issues around recreating the voice or appearance of deceased people as chatbots?

Category	Learn	Explore	Think
AI-Generated Media AI technologies are being used to generate voices, images, deepfake videos, and even news.	Video: "Sway Launches #CoolRanchDance in Partnership with Doritos: Join the AI Dance Challenge!" Video: "Behind the Scenes: Dali Lives" Interactive Game: Choose Your Own Fake News Article: "What are Deepfakes?" Article: "Should AI Bring Dead Voices To Life?"	This Person Does Not Exist: Refresh to see AI-generated human faces. This Cat Does Not Exist: Refresh to see AI-generated cats.	Some people think that fake content can be as harmful or malicious as cybersecurity breaches, and that corporations and governments should act accordingly. In what ways is this true or untrue? How does fake media affect our ability to know what is real? Does it matter who owns voice and image data on you? Would it matter if it was the government vs a corporation? A local vs a foreign company? For profit or not-for-profit?
AI Personalization Machine learning allows AI technologies to use data about you and people like you in order to personalize things like educational intelligent tutoring systems, targeted advertisements, media recommendations, and search engine results.	Video: "Recommender Systems: How YouTube Knows What You Should Watch" Article: "What is Targeted Advertising?" Article: "How 'Intelligent' Tutors Could Transform Teaching"	Google Ads Settings: If you log-in to a Google account, you can see how the company is personalizing the ads you are shown. Flexi: See ways the Flexi intelligent digital math tutor not only provides hints, reminders, and support, but also adapts the practice with harder or easier follow-up questions based on how you answer the previous problems. Learn more about how it works here.	What are the ethical impacts of personalized results that manipulate human behavior through recommendations or nudges? Should people be worried about the amount of time spent watching the videos or consuming other media recommended to us by AI algorithms?
AI-Generated Art Using AI tools, people can create visual art, music, poetry, choreography, or other works of art—even in the style of other artists.	Article: "Would You Buy This AI Painting?" Article: "Computers are Changing How Art is Made" Article: "What is AI Generated Art?" Article: "AI can make music. But will it replace your favorite musician?" Article & Videos: "12 Songs Created by AI"	Demo: MuseNet Demo: AI Duet Demo: Doodles to Pictures	Does AI-generated art count as art? Who should own or get credit for the AI-generated artwork?

Category	Learn	Explore	Think
AI Automation AI technologies are automating tasks that were previously performed by living, intelligent beings like humans and animals.	Video: "Microsoft is accelerating the journey from automated to autonomous systems" Article: "How Will Automation Impact Our Lives?" Article: "A robot referee can really keep its 'eye' on the ball" Article: "How to fight online hate before it leads to violence" Article: "Moral dilemma could limit appeal of driverless cars" Webpage: Automated Vehicles for Safety	Moral Machine: Try making ethical decisions for an autonomous vehicle	In what situations might it be an ethical problem to have automated AI technologies perform tasks previously completed by human workers, and why? How should people decide when automated technology should be used (e.g., if the AI does it faster, with less errors, performs a task that is dangerous to humans, works without bias, etc.)?
AI Assistive Technologies AI can be used to power technologies that help people with diverse needs and abilities.	Video: "Seeing AI: Making the visual world more accessible" Video: "How to Translate Spoken Word into Sign Language on Your Phone" Article: "Computers can translate languages, but first they have to learn" Webpage: Microsoft.com AI for Accessibility	Present Slides with Captions: Follow these directions to have machine learning generate captions while presenting Google Slides Using Microsoft Translator in a presentation: Follow the directions to have machine learning generate subtitles in a language of your choice while presenting PowerPoint slides	Do you think assistive technologies will help or hinder human intelligence in the long run? Should machines decide who to help and who to harm?

Category	Learn	Explore	Think
AI Recognition When we talk about AI recognition, we are talking about AI algorithms that use patterns to correctly identify and label images, sounds, or text.	Video: "Gender Shades" Article and Video: "New device tells smiles from frowns–even through a mask" Article: "Researchers Are Using Facial Recognition Software To Save Lions" Article: "Artificial Intelligence: From Croissants to Cancer" Article: "Facial recognition technology: The need for public regulation and corporate responsibility"	Google Lens or Google Search by Image Erase Your Face	Since greater surveillance leads to more data collection, which leads to more accurate AI, how should we find a balance between data privacy and technological advancement? Should people be worried about a few companies or governments owning or accessing tremendous amounts of data about people?

NOTE: Following student presentations, if time does not permit you to do Activity 4 and 5, skip to the class discussion in Activity 6: Reflect.

Activity 4: AI Policymaking

In the last activity, students explored the pros and cons of various AI technologies, revealing how those technologies are able to help people, but also how they might cause harm or ethical dilemmas. In this activity, students will consider whether policies or regulations might help ensure that AI technologies are only used for good.

1. Summarize what students learned in the last activity, sharing that AI can be beneficial if it helps people in a society and aligns with their values, but it can be dangerous if it is programmed to do something harmful or if it is destructive in how it achieves something good.
2. Tell students that many industry, government, and civic organizations are advocating for or establishing guidelines, policies, regulations, and laws to ensure the ethical design and use of AI. While violating some of these regulations, like the United States Federal Trade Commission (FTC) regulations, might come with legal consequences for a company; others policies, such as a company's code of ethics, are simply goals the company internally strives to abide by, and there may not always be consequences for violations. Share the list of resources below (or other policy resources) and give students some time to explore them. Tell them to select two to explore more closely.
   - USA Federal Trade Commission Guidance
   - European Union's Ethics Guidelines for Trustworthy AI–Press Release

- Hong Kong's Ethical Accountability Framework
- Artificial Intelligence at Google: Our Principles
- Microsoft's Responsible AI page
- IBM: Everyday Ethics for Artificial Intelligence
- Partnership on AI's Goals and Thematic Pillars
- USA Children's Online Privacy Protection Act (COPPA): FAQs on COPPA and Schools
- The Institute for Ethical AI in Education's The Ethical Framework for AI in Education

3. Using a Venn diagram, have students compare and contrast the two examples they selected. They do not need to read the resources in their entirety, but should instead try to find main ideas about how their examples address topics like bias, fairness, transparency, explainability, accountability, or values. Once students have completed their diagrams, have them share some of the common themes they found throughout the ethical guidelines they examined.
4. Tell students that one recent innovation proposed by Google to help address these issues is called model cards. **Model cards** provide a holistic framework for sharing information about machine learning model, such as its purpose and audience, design and training data, implementation limitations, and trade-offs. Google suggests these model cards can be created by many developers and will improve transparency about an AI for various stakeholders. Take a closer look at two examples of Google's model cards **here**.
5. Conclude this activity with a class discussion about ethical responsibility with AI, using the questions below. Help students to understand that all stakeholders, even users, share responsibility for ethical AI design and use. All stakeholders have a role to play in determining how AI will be used in the future.
   - Which do you think would be more effective: private companies regulating themselves, or the government enacting laws to regulate the design and development of AI? Why?
   - Who is responsible for making sure that AI is designed and implemented ethically? Who should be responsible? Why?

CULMINATING PERFORMANCES

Activity 5: Getting Engaged in AI Policymaking

In this culminating performance, students will synthesize what they learned in this project to articulate and support a position on an AI policy. Depending on your personal teaching style and your students' interests, you could do one or both of the listed activity options. Both activities reinforce the importance of digital citizenship and advocacy in an AI-infused world.

1. Kick off the final section of this project by introducing students to the concept of digital citizenship. According to the ISTE Standards for Students, a good digital citizen is someone who "recognize[s] the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and

they act and model in ways that are safe, legal and ethical." This is a critical skill, especially in an increasingly AI-powered world.

2. The DigCitCommit Coalition defines five digital citizenship competencies: inclusive, informed, engaged, balanced, and alert. Have students watch the 30-second video "Commit to Digital Citizenship!" to introduce these concepts. Display the list of five competencies on the board and ask students to share how they see these concepts relating to what they have learned about AI in this project.
3. Tell students that they will have a chance to put all five competencies into action during the remainder of the project activities, especially the "engaged" competency, defined as "the ability to use technology and digital channels for civic engagement, to solve problems and be a force for good in both physical and virtual communities." In both options, they will think about various **calls to action**—statements telling someone what next step they should take—that stakeholders might ask policymakers to take.

Option A: Mock AI Regulatory Council Meeting

In Culminating Performance Option A, students will apply what they learned from the last activity as they consider policy and regulation around the development and use of AI technologies. Students will role play stakeholder advocates and policymakers during a critical meeting of a fictional global agency—the World AI Regulatory Organization (WAIRO). This activity can be as straightforward or elaborate as your time and learning environment allow.

1. Introduce this activity by letting students know that they will be applying the research they gathered in the last activity as they role play in a mock global regulatory council meeting of the fictitious, but potentially very influential WAIRO. Explain that this activity mirrors what it might look like for a stakeholder representative to advocate for their constituents in front of a school board, city commission, or legislature.
2. Establish the roles of the WAIRO meeting.
    - **3–5 Council Members.** These students will sit at the front of the room, listen to comments shared by various stakeholders, and attempt to work together to create a unifying AI regulatory policy for the world. (For an interesting alternative implementation of this activity, school leaders or community members could serve as the council members.)
    - **3–7 Stakeholder Representatives.** These students will present three-minute arguments to the council members regarding exactly how a particular stakeholder group would like them to decide about AI regulation. Possible stakeholder groups include: children under 13, middle and high school students, consumers, large AI software corporations, small AI-powered start-ups, humanitarian organizations, environmental activists, government organizations, or any other stakeholders that came up during Activity 3.
    - **Stakeholders.** The remainder of the students should form partnerships or groups with the stakeholder representatives to help them prepare their comments for the council.

3. Give students time to prepare for the mock meeting. Encourage students to draw from the resources they explored in previous activities for concrete examples and supporting evidence as they determine how someone in their role would think about the types of policies or regulations to be addressed.
4. During the mock meeting:
    - Allow each stakeholder representative three minutes to present their argument to the council. Optionally, also give the council members time to ask follow-up questions of the stakeholder.
    - Give the council members 10–15 minutes to deliberate and create a policy resolution on AI use, rights, or restrictions. This list might include dos and don'ts, as well as indications of whether violations would be considered civil or criminal violations or incur any type of punishment. The rest of the class should serve as an audience to these discussions. The final policy resolution should only include what the council members can agree on during the given amount of time.
5. Following the mock meeting, debrief using the following questions:
    - Based on the policies or regulations the WAIRO council passed, how might each of the stakeholder groups be impacted?
    - If the council could not agree on certain policies or regulations that were requested by the stakeholder representatives, how might this lack of action impact the stakeholder groups?
    - Looking at the names and descriptions of the five digital citizenship competencies, how do you see these skills playing a role in the development of AI policy?

Option B: An AI Call to Action

In Culminating Performance Option A, students considered multiple stakeholder viewpoints and how they might be affected by various AI policies or regulations. In option B, students will take a personal AI policy position and communicate it through a media artifact.

1. Have students work as individuals, with partners, or in small groups to create an artifact that advocates for a specific AI-related call to action. The artifact might be a letter, a persuasive essay, a blog, a video, a podcast, or other medium of their choice. The artifact should include:
    - **Who:** A specific policymaker audience, such as parents, school leaders, state leaders, company or business leaders, or government officials.
    - **What:** An audience-specific call to action, such as: developing a specific policy or regulation; learning more about particular AI topics; bringing in a guest speaker or consultant; adding AI education to the school curriculum; training teachers and students about AI data privacy; or, using an AI in a specific way to help people.

- **When:** A suggested timeline for executing this action.
- **Why:** At least two examples of supporting evidence that explain why this call to action is needed, why it will benefit people, and why the benefits of this policy will outweigh the potential risks or harms.

> **NOTE:** It is likely that some students will advocate for positions that seem unethical in some way. When evaluating this assignment, consider whether they met the assignment criteria, whether their supporting evidence aligns with their call to action, and whether they establish an argument for the way the harms in their trade-off are outweighed by the benefits of their call to action.

2. Once students have created their artifacts, have them share them with the class using a gallery walk or class presentation format. Optionally, students may choose to share their artifact with the audience they selected.

Activity 6: Reflect

In this activity, students discuss the following questions.

- Is the ethical thing to do always obvious or self-evident? How might different stakeholders perceive the same decision about fair and ethical AI design or use differently?
- What happens if policymakers can't agree on or choose not to act on regulations regarding how AI should be used? What might be the consequences of not creating policies or regulations to govern ethical AI design and use?
- How will you continue to learn about and advocate for ethical design and uses of AI?

Extensions

Following are three ways to expand students' exploration of AI and the ethical considerations raised in this project:

1. Extend students' thinking about the ethics and societal impact of using AI technologies by teaching projects from other guides in the *Hands-on AI Projects for the Classroom* series. Depending on which topic you'd like to explore next, here are several projects to explore:
   - Boost students' media literacy skills by further exploring how AI is used to create and disseminate information, misinformation, and disinformation in the "Developing a Critical Eye" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers*
   - Learn about ways that AI can solve real world problems and foster social good in the "Using AI to Solve Environmental Problems" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers.*
   - Further consider ethical AI business practices and overarching principles for AI policy through the "Laws of AI" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers.*

- Consider several ethical questions around the use of automation and robotics in the "Using AI for Robotic Motion Planning" project found in *Hands-on AI Projects for the Classroom: A Guide for Computer Science Teachers*.

2. Continue the conversation about various aspects of digital data privacy with resources from the International Computer Science Institute at **teachingprivacy.org**.
3. Further explore how AI technologies express the creator's values and affect various stakeholders through the following student curriculum developed at MIT: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students.**"

> I love that the advanced preparation section provides teachers with options depending on how much time they have to teach the topic and specifically lays out which activities should be completed based on time available. It can also be used as a full unit. I also love the suggestion of how to use this as a cross-curricular project, which can really help teachers envision how they can incorporate AI into their classrooms. It's a wide range of options, which I think is great to provide these ideas to teachers to help them plan as they integrate this project into their curriculum. It's a great project that hits so many areas of AI and the resources provided are excellent!
>
> —Coral Zayas, Dual Language Teacher (K–12), Leander ISD

> One suggestion I would give to teachers who use this project is to go through the resources yourself first and pick the ones that your students will connect with most. Also, don't be afraid to remix the activities and allow your students to explore this topic. It will be a time of great learning for you and the students.
>
> —Brandie Wright, Middle School Technology Education Teacher, Dozier Middle School

PROJECT 4

AI and the 21st Century Worker

In "The Future of Jobs Report 2020," over 80% of the companies surveyed indicated they will be using AI technologies by 2025. Furthermore, the report estimates that by 2025, "85 million jobs may be displaced by a shift in the division of labour between humans and machines, while 97 million new roles may emerge that are more adapted to the new division of labour between humans, machines and algorithms." Applications of AI technologies in this evolving workforce environment raise a variety of ethical questions that today's students should explore.

> I'm excited about this project because it gets students to think about their future in a practical way and gives them the resources and mindset to make predictions about the changing world around them. One suggestion I would give to teachers who use this project is to experiment with how they run the discussions. There are so many great discussion questions throughout this activity, and it is a great way to see how students engage when presented with different formats like small groups, whole class, or online forums.
>
> —Eamon Marchant, teacher and site tech coordinator, Whitney High School

Project Overview

The "AI and the 21st Century Worker" project provides students with a series of learning activities that build on their prior knowledge of AI applications to explore how AI technologies might impact school and work life, now and in the future. Through videos, simulations, class discussions, research, and a little imagination, students will learn that all applications of artificial intelligence come with trade-offs and that it will take diversity, inclusion, and unbiased decision-making to foster a positive and ethical impact of AI on society.

SUBJECT

Technology, Computer Science, English Language Arts, or Career Exploration

ESTIMATED DURATION

6–13 hours

TARGET GRADES

8–12

VOCABULARY

bias
ethics
ethical
futurist
machine learning algorithm
stakeholder
training data

OBJECTIVES

At the end of this project, students will be able to:

- Describe ways that artificial intelligence is positively and negatively changing schools and industries.
- Explain the roles of bias, equity, diversity, and inclusion in the development of ethical AI.
- Predict ways that AI might impact the workforce of the future.

STANDARDS

ISTE Standards for Students

2. Digital Citizen

d. Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.

4. Innovative Designer

a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

5. Computational Thinker

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

ISTE Computational Thinking Competencies

1. Computational Thinking

e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. Equity Leader

b. Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.

e. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

4. **Creativity & Design**
   - **b.** Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.
5. **Integrating Computational Thinking**
   - **b.** Empower students to select personally meaningful computational projects.

AI4K12 Five Big Ideas in AI

3. **Learning**
   Computers can learn from data.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

CSTA K–12 Computer Science Standards

2-DA-09: Refine computational models based on the data they have generated.

2-IC-20: Compare trade-offs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21: Discuss issues of bias and accessibility in the design of existing technologies.

3A-IC-24: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.

3A-IC-25: Test and refine computational artifacts to reduce bias and equity deficits.

3B-AP-08: Describe how artificial intelligence drives many software and physical systems.

3B-IC-25: Evaluate computational artifacts to maximize their beneficial effects and minimize harmful effects on society.

3B-IC-27: Predict how computational innovations that have revolutionized aspects of our culture might evolve.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.W.6.1 through 11-12.1: Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-LITERACY.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

CCSS.ELA-LITERACY.WHST.9-10.7/11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online
- Writing materials such as paper, pens, pencils
- Online articles, tools, and resources listed below
- Sticky notes
- Optional: Printing capabilities for student work in Activity 3

SUPPORTING RESOURCES FOR EDUCATORS

- Article: **"Top 9 ethical issues in Artificial Intelligence"**
- Article: **"Design Thinking for Educators"**

ADVANCED PREPARATION

- Complete the **Most Likely Machine** interactive to understand how the user's decisions affect the outcomes in the simulation.
- Complete the **Survival of the Best Fit** interactive simulation to see how students will explore the concept of bias as they train an AI to review resumes and make hiring decisions.

Instructions

GETTING STARTED

Activity 1: AI in Schools

In this activity, students will activate their prior knowledge about the impact of AI by considering how artificial intelligence tools affect how students go about their daily life and work as middle or high school students.

1. If students are unfamiliar with AI technologies, you should begin this activity by explaining what artificial intelligence is and how it works. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
2. Display this list of real examples of AI technologies that impact students during the modern school day. Ask the class, "How many of these real-world examples of AI technologies are already in use during your school day?" Make a tally of how many are in use.
   - GPS or map apps to check traffic on the way to school
   - Self-driving car taking staff or students to or from school
   - Intelligent tutoring software like Khan Academy or iReady

- Chatbots to provide tech support or answer frequently asked questions on the school website
- Autocorrect or spellcheck
- Auto-completion of text in emails or class writing assignments
- Search engine to do class research
- Recommender systems on YouTube or TikTok to find videos explaining concepts for school
- Retinal scans to take attendance
- Facial recognition to measure if students are paying attention in class
- Translation software to understand a word or phrase in another language
- Cognitive assistants (like Siri or Alexa) to make a calculation or give you a fact for class
- A writing helper like Grammarly for proofreading and making suggestions to improve student essays
- Digital filters to edit photos or art for projects
- Teachers using Turnitin or another AI-powered program to check if student submissions include plagiarism
- Sensors to monitor usage of class materials or students' traffic patterns in hallways
- Smart watches to measure your fitness or steps during the school day
- Smart devices used for school safety
- Algorithms in LinkedIn or other software to help match a student with a compatible employer for a high school job

3. Hold a class discussion to explore how the AI technologies examined are impacting education. Ask the following question:
   - How many of these technologies do you want to be used in schools? Are there any that you don't want to be used? Why or why not?
   - How did these tasks get done in the past? How else might AI affect the school day of preteens and teenagers in the future?
   - How is AI affecting how you go about your daily life and work as a middle or high schooler?
4. Tell students that another way that AI is being used is to screen applications for colleges, universities, and technical schools. An algorithm is developed to decide which applications represent the best candidates for their institution. Ask students, "Do you think an AI or a person would make a more accurate decision about which students will be the most successful, and why?"
5. Have students complete the Most Likely Machine simulation individually or with a partner. In this activity, students build their own **machine learning algorithm** for determining which historical figures (here called "students") are the best fit for certain superlative titles, such as "most likely to go to a top university." A machine learning algorithm is a process or set of rules used by an artificial intelligence to find and apply

patterns in data. Following their experience, ask students to indicate whether they think it is right or wrong (or beneficial vs. dangerous) to have an AI make decisions about students' futures. It is likely that students will collectively have mixed feelings about this. Tell them there is not one correct answer to that question, and it's okay if they disagree with each other about it.

6. Tell students that in this project they will continue to explore the ways that AI technologies are shifting the way people work, not just in schools, but in the workforce as well. In the process, they will often stop to ask themselves questions about whether these impacts seem good or bad, and why. These are considered ethical questions. **Ethics** is the study of the moral principles and systems that govern a person's behavior. It is the study of the systems people use to determine what is right and wrong. When people say that something is the **ethical** thing to do, they typically mean that they believe it is the morally right thing to do. In this project, students explore the impact of AI technologies on society and decide for themselves whether they think these changes are ethical—or good—for our society.

TAKE A CLOSER LOOK

Activity 2: The Changing Workforce

In this activity, students will consider how AI is impacting the modern-day workforce as they watch videos, hold class discussions, and complete an **affinity diagramming activity**.

1. Display the question "How is AI impacting the workforce?" on a whiteboard, bulletin board, or wall.
2. Give five or six sticky notes to each student. After students experience the resources listed below, have them write down facts or ideas on the sticky notes about what AI can do or how AI is impacting jobs. Each sticky note should list only one fact or idea.
    - Play the videos "**Humans Need Not Apply**" and "**Humans and AI Working Together,**" or other video clips that provide an overview of how AI is being applied in ways that affect today's workforce.
    - Share the following facts from "The Future of Jobs Report 2020" (**full report**; **list of key findings**).
        - Over 80% of companies surveyed for the report believe they will be using artificial intelligence technologies by 2025. And nearly 50% of the companies surveyed in the automotive, education, financial services, and healthcare sectors say they will be using humanoid robots by 2025.
        - "Forty-three percent of businesses surveyed indicate that they are set to reduce their workforce due to technology integration, 41% plan to expand their use of contractors for task-specialized work, and 34% plan to expand their workforce due to technology integration. By 2025, the time spent on current tasks at work by humans and machines will be equal."
        - "We estimate that by 2025, 85 million jobs may be displaced by a shift in the division of labour between humans and machines, while 97 million new roles may emerge that are more adapted to the new division of labour between humans, machines and algorithms."
        - "For those workers set to remain in their roles, the share of core skills that will change in the next five years is 40%. 50% of all employees will need reskilling (up 4%)."

- "94% of business leaders report that they expect employees to pick up new skills on the job."
- "The top skills and skill groups which employers see as rising in prominence in the lead up to 2025 include groups such as critical thinking and analysis as well as problem-solving, and skills in self-management such as active learning, resilience, stress tolerance and flexibility."

3. After writing down their ideas, have students place the sticky notes under the posted question. Work with students to organize the notes into categories by discussing how they might label different types of impacts. Then cluster their ideas using the categories they identify. Discuss the major themes that arise, including questions such as:
   - What types of jobs might be eliminated over time by automation or AI technologies?
   - What would be the pros and cons of a society where so much work is automated that many people are not needed to fill jobs?
   - Why might people want to keep doing tasks that can be done by automation or AI? (Does anyone still hand wash dishes even though they have a dishwasher? Or choose to checkout with a cashier even when there is an available self-checkout lane? Why?)
   - What are some of the new types of jobs that are being created because of automation and AI technologies?
   - What might be the benefits of humans and AI agents working together?
4. Tell students to look at the categories and sticky notes again, this time through an ethical lens. Explain that sometimes the same AI technology, application, or change might be beneficial to some people and detrimental to others. The people who have an interest in, who can affect, or who are affected by an AI technology are called **stakeholders**. Stakeholders include not just the users, but also the developers, salespeople, owners of the company, the environment, the government, or anyone else impacted by its use.
   - Draw a line across the top of the board. On one end, write "positive impact." On the other, write "negative impact." Explain to students that this line represents a spectrum that the ideas they wrote down might fall on. The two ends represent the extremes, while something in the middle might be balanced or have equally strong tradeoffs on both sides.
   - For each sticky note, ask, "How does this impact reflect positive changes that are benefiting one or more stakeholders? How does this impact reflect negative changes that are detrimental to one or more stakeholders? Do you think the overall effect of this impact is positive (benefits outweigh the harms), negative (harms outweigh the benefits), or neutral?"
   - Have the students work as a class to place the sticky notes on the spectrum, justifying the position by explaining how they took various stakeholders' perspectives into account.
5. Keep the sticky notes displayed (or take a photo of the display), and let students know they will return to this activity at the end of the project.

Activity 3: Careers Working with AI

In the previous activity, students discussed how some jobs will be eliminated by AI technologies, while new jobs will emerge. In this activity, students explore why diversity in the people who hold AI-related jobs is important, then learn about people from diverse backgrounds who are making a positive impact through their work with AI technologies.

1. Have students watch the video "**Ethics & AI: Equal Access and Algorithmic Bias.**" Following the video, ask students to share their takeaways. Highlight the following key points:
   - AI technologies can sometimes negatively affect those who are the most vulnerable or the most marginalized. To limit the harm of these technologies, we must consider those most likely to be hurt by the system.
   - When nearly everyone has a computer in their pocket, it's possible to imagine a world where AI technologies could be benefiting everyone. To achieve that, we need to give a greater voice to those being impacted, so that their input impacts AI development.
   - AI development jobs need to be filled by people with diverse perspectives, such as more women and more people of color. This not only provides an opportunity for them to apply new lenses to approaching the world's problems, but also makes sure that AI solutions are designed with them in mind. (Note: While the video specifically mentions women and people of color, this would be a great time to mention increasing diversity by including people from other traditionally underrepresented populations in STEM fields, such persons with disabilities, who identify as LGBTQ+, or who come from lower socioeconomic backgrounds.)
2. Have students work independently or with a partner to read an article about someone who has contributed to or succeeded in the field of AI, such as those listed on the **AI4All Role Models in AI** webpage. Students should learn a little about the person, as well as what they have accomplished in the AI field. This is also an opportunity to showcase the successes of AI contributors from diverse backgrounds. Students can take notes in a graphic organizer, or they could create a set of AI Role Model trading cards using a digital tool like the **ReadWriteThink Trading Card Creator**. Students can print and display the cards, or share them in a digital gallery for other students to explore.
3. Tell students that because of available AI tools, models, and datasets, they don't have to wait until they are in a career to create AI applications that can help solve a problem in their life, school, or community. In fact, children and teenagers around the world have already begun to develop their own programs and apps that integrate AI to solve real world problems. (If time permits, consider sharing examples like high school student **Michelle Hua's Coach AI** or high school students **Owen Scott, Drew Kinneer, Arya Karnik, and Sabarish Mogallapalli's ChestML**. Both of these projects were recognized as winners in the annual **Congressional App Challenge**.)

Activity 4: AI Decision-Making

In this activity, students will explore ethical considerations about how AI is being used to automate decisions about hiring and firing in the workforce.

1. Tell students that in addition to automating tasks and ushering in new types of jobs, AI is also changing the workforce by making decisions about schooling and job placement. Artificial intelligence technologies are currently being used by many organizations to automate high school course placement, screen college applications, and make hiring and firing decisions.
2. Have students complete the **Survival of the Best Fit** simulation game about hiring bias in AI. In this simulation, students step into the hiring role of a new start-up. At first, they make hiring decisions themselves, but as the business grows, they train and implement an AI algorithm to make the decisions for them.
3. Following the simulation, explain to students that **bias** is a preference for or against an idea or thing. We all have biases—preferences towards everyday things like cats or dogs, sweet or salty, sun or rain, as well as about harder trade-offs such as whether it is better for a woman to be a stay-at-home mom or be part of the workforce. While we are aware of some of our biases, others are **unconscious biases**—opinions or decisions that are formed about people or things without consciously learning or thinking about them. Whenever we use an artificial intelligence to make decisions, the decisions reflect any biases found in the **training data** (examples used to teach the machine learning model) that humans collected, selected, and used.
4. Further explore the idea of bias in AI decision-making by sharing historical or current event articles that reveal the applications and outcomes of real world organizations using AI for hiring or firing. Resources to support this discussion might include:
   - Article: "**AI programs exhibit racial and gender biases, research reveals**"
   - Article: "**AI at work: Staff 'hired and fired by algorithm'**"
   - Article: "**Amazon scraps secret AI recruiting tool that showed bias against women**"
   - Article: "**The Key Role Evolving AI Will Play In Tech Hiring And Firing**"
   - Article: "**How AI Can Remove Bias From The Hiring Process And Promote Diversity And Inclusion**"
5. Hold a class discussion, exploring the following questions:
   - How does the use of AI for making hiring and firing decisions impact stakeholders? Who does or does not benefit, and why?
   - How do AI machine learning algorithms inherit the biases of the humans who create them?
   - How might the use of machine learning algorithms reinforce inequities that already exist in the world?
   - How might knowing that an AI could be screening a resume or application change how you or others fill out applications?
   - If people better understand how machine learning algorithms are trained, how might we use machine learning algorithms more ethically for decision-making? How might we use them to overcome biases in the world? How might we create accountability for those who develop and use them?

CULMINATING PERFORMANCES

Activity 5: Jobs of the Future

In this culminating performance, students will step into the job role of a futurist. They will combine research with imagination to describe the evolving knowledge, skills, and credentials they believe will be needed for jobs of the future.

1. Introduce this activity, letting students know that they will be stepping into the role of a **futurist**: someone who uses research on current trends to make predictions about the future. This task will require both research and a lot of imagination.
2. Have students work individually, with a partner, or in a small group to complete the following steps:
   - Select a job or field of your choice.
   - Based on the assumption that AI will affect every job and field, use a **design thinking framework** like the one outlined below to research and develop your ideas.
     - **Discovery.** Research the selected job or field, using resources like the **U.S. Department of Labor's Career One Stop**, **My Next Move**, or **Project STEM's Real-World Career Connections**. What core tasks do these workers do day-to-day? How is AI currently being used in this job or field? Do they use, train, and/or develop AI tools? What is the current pathway for getting into this career? What knowledge, skills, or credentials are needed?
     - **Interpretation.** Based on what you learned, what trends do you notice? What changes are already occurring because of AI technologies?
     - **Ideation.** Generate ideas about how this job or field might look in 10 or 25 years. What will be the core tasks performed and how will AI be involved? How might the pathway to this career change? What knowledge, skills, or credentials will be needed? In your opinion, how might these changes positively and/or negatively impact various stakeholders or society as a whole?
     - **Experimentation.** Share ideas with a classmate and get their feedback. Do your ideas seem possible? Are they an effective combination of the research and your own ideas? What other suggestions do they have for improving your predictions?
     - **Evolution.** Consider the peer feedback and improve your predictions by revisiting any of the previous design thinking steps.
   - Select the best way to advertise a future job in the field you selected, such as an online job listing or a video. Develop an advertisement that includes, at a minimum, the future job description as well as the knowledge, skills, and credentials needed to be qualified for the job.
   - Have students present their future job advertisements to the class. After each presentation, discuss as a class whether they think the specific predicted changes would be beneficial or detrimental to various stakeholders or to society, and why.

Activity 6: Reflect

In this activity, students should discuss the following questions to reflect on the societal impact of AI technologies on work in the digital age.

- Looking at how the class placed the sticky notes on the positive and negative impact spectrum at the beginning of the project, are there any ideas that you would move now that you know more? Why?
- Why is having a diverse workforce in AI development important to the development of ethical AI design and application?
- How might society be negatively impacted by the ways AI technologies are changing today's workforce? How might society be positively impacted?
- Just because an AI *can* be used to do something, does that mean an AI *should* be used to do it?
- What next steps will you take to continue learning about the ethical impact of AI technologies on life and work?

Extensions

Following are four ways to expand students' exploration of AI and ethics topics raised in this project:

1. If time permits, consider sharing the PBS documentary "**CyberWork and the American Dream**" during Activity 2, or following the completion of the project. This documentary offers one way to explore the history of industrial development in the United States, examine ways that robotics and AI are currently impacting the future of work; debate presented perspectives and how these trends might affect jobs of the future; and consider what might be done to prepare for the challenges these potential shifts present.
2. Further students' understanding of machine learning and bias by teaching the "Programming with Machine Learning" project found in the *Hands-on AI Projects for the Classroom: A Guide for Computer Science Teachers*. In "Programming with Machine Learning," students create and select data, train a model, test for bias, and iterate to improve their program. Its activities could be inserted at the end of Activity 3 during this project to add an interactive programming element, or used as a follow-up.
3. Extend students' thinking about ethics and using AI technologies to make a positive societal impact by teaching projects from other editions of *Hands-on AI Projects for the Classroom*. Depending on which topic you'd like to explore next, here are several projects to explore:
    - Discover ways that AI capabilities can be harnessed to solve practical problems in the "Design an AI Agent" project found in *Hands-on AI Projects for the Classroom: A Guide for Electives Teachers*.
    - Consider how chatbots, like virtual assistants and conversational agents, can automate tasks traditionally performed by humans in the "AI Chatbots" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers*.

- Explore ways that AI can solve real-world problems and make a positive environmental impact in the "Using AI to Solve Environmental Problems" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers*.

4. Inspire students to further explore careers in computer science and AI by inviting a guest speaker, using connections with local businesses or an online program such as **Amazon Future Engineer Class Chats**.

> I teach computer science and career preparation 9–12 and I can clearly see how beneficial this project will be for students. The activities are very engaging and the content is relevant and easy to understand. I feel that the two interactive simulations are great to help students understand the possible scenarios and have a better picture of the context where this is applicable.
>
> —Betzabé Orenos, High School Innovation Teacher and Instructional Coach, Colegio Decroly Americano

Glossary

active data collection: data you know you are leaving behind and may expect to be seen or used by others (also called footprints).

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

bias: preference for or against an idea or thing.

call to action: statements telling someone what next step they should take.

data: information

dataset: collection of data.

data trail: a dataset of personal information tracked through a person's actions online

ethical: morally right.

ethics: the study of the moral principles and systems that govern a person's behavior.

feature: unique measurable property.

futurist: someone who uses research on current trends to make predictions about the future.

machine learning algorithm: a process or set of rules used by a computer to find and apply patterns in data.

model card: a holistic framework for sharing information about machine learning model.

passive data collection: data that you probably don't think about or expect to leave behind, but is nevertheless being collected or tracked by the application (also called fingerprints).

recommender system: a computer program that makes suggestions about products, services, or other information users might like based upon data collected about the individual person or groups of people who are similar to the person getting the recommendation.

social good: something that benefits the largest number of people in the largest possible way.

stakeholder: those who have an interest in, who can affect, or who are affected by something

stereotype: a fixed general idea or image of someone or something.

survey: a way to collect information by asking people what they think or know about something, and using that information to make decisions or predictions using that information.

targeted marketing: the process of identifying people who are most likely to respond positively to advertisements, recommendations, and other information expressing specific points of view and then identifying the most likely strategies for reaching those people (e.g., print, radio, television, online).

trade-off: a balance or compromise between two or more desirable, but competing or incompatible options.

training data: examples used to teach a machine learning model.

unconscious bias: opinions or decisions about people or things that are formed without consciously learning or thinking about them.

APPENDIX A

Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and "Big Hero 6"'s Baymax.

Learn More

Video: "**What is AI (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**". This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human

language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students**"

Video: "**Algorithmic Bias and Fairness #18**"

Article: "**Ethical Concerns of AI**"

Article: "**Top 9 ethical issues in Artificial Intelligence**"

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

APPENDIX B

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science				Ethics			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ISTE STANDARDS																				
1.1 Empowered Learner	x	x					x			x	x	x	x		x	x		x	x	
1.2 Digital Citizen					x			x			x			x			x	x	x	x
1.3 Knowledge Constructor	x		x	x		x	x	x			x		x				x	x	x	x
1.4 Innovative Designer		x	x				x		x	x					x	x			x	x
1.5 Computational Thinker			x	x	x		x		x		x		x	x	x	x	x			x
1.6 Creative Communicator					x	x		x			x			x					x	
1.7 Global Collaborator							x					x	x						x	
5.1 Computational Thinking				x	x	x	x		x	x	x	x	x		x	x	x	x	x	x
5.2 Equity Leader					x	x	x	x							x	x	x	x	x	x
5.3 Collaborating Around Computing	x			x			x					x	x							
5.4 Creativity & Design	x	x	x	x				x	x	x	x			x	x		x		x	x
5.5 Integrating Computational Thinking		x	x				x		x	x				x						x

Guide	Elementary				Secondary				Electives				Computer Science				Ethics			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
AI4K12 FIVE BIG IDEAS IN AI																				
Perception	x	x			x					x		x			x				x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x				x	
Learning	x			x		x	x				x	x	x	x	x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x				x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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Hands-On AI Projects for the Classroom

A Guide for Computer Science Teachers

ISTE

GENERAL MOTORS

Hands-On AI Projects for the Classroom

A Guide for Computer Science Teachers

About ISTE

The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

Related Resources

Teaching AI: Exploring New Frontiers for Learning by Michelle Zimmerman

ISTE online course, *Artificial Intelligence and Their Practical Use in Schools*

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Contents

Foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem-solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, artificial Intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large data sets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in **Appendix A: Unpacking Artificial Intelligence**.

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from jmc.stanford.edu/articles/whatisai/whatisai.pdf

Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority of them are focused on two general areas: automating administrative tasks, such as taking attendance and grading assignments, or increasing student performance through AI-supported assessment, personalized learning, and increasing engagement in typically mundane rote learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of this guide is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users and even creators of these powerful tools.

This guide is for educators who teach computer science. Once the stuff of science fiction, AI innovations now permeate nearly every facet of modern software development and computational thinking. For example:

- Machine learning powers applications that run classification features, such as spam filters, and predictive features, such as shopping and entertainment recommenders.
- Bots and non-player characters (NPC) in video games use AI to demonstrate human-like behaviors and improve performance.
- AI automation software is combined with robotics to efficiently perform tasks in a warehouse or drive autonomous vehicles.
- Complex machine learning models are abstracted into user-friendly interfaces for customization and integration into websites and apps by organizations and companies both large and small.

As AI is increasingly recognized as a fundamental building block for computing solutions, K–12 computer science students who may someday be writing AI algorithms, training AI models, and developing AI applications should receive more advanced instruction on the workings and challenges of this evolving technology. The projects and resources in this guide provide detailed scaffolding to connect foundational AI knowledge with the computer science concepts and standards that middle and high school computer science teachers are already familiar with. Each project is an entry point for teachers and students to co-learn and expand their knowledge of the field of AI, and each project provides possible extension paths for taking that learning further. As computer science students engage with the projects in this guide, they will discover their own potential to use AI as a computing tool to advance their ability to develop software that solves problems in their life, community, and world.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach

The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their understanding of how AI technologies work, and create various authentic products–from machine learning models to video games—to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the standards, concepts, and depth that would be appropriate to computer science courses. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education, exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in computer science or AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, the Programming with Machine Learning project can be completed by students in either middle school or high school; however, older students should be presented with a deeper understanding of how machine learning works and how it can be integrated into computational solutions. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI (shown in Figure 1).

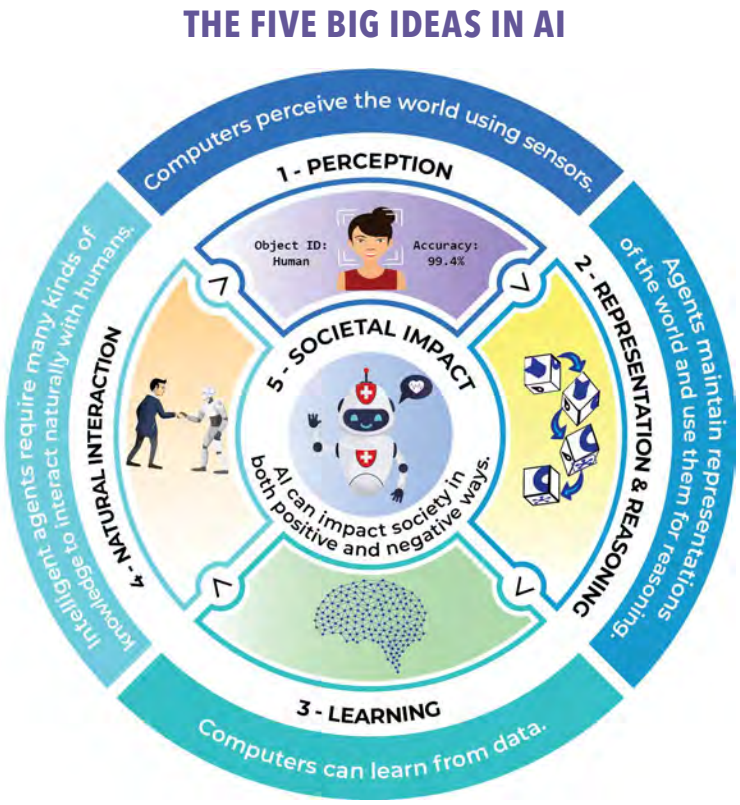

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

The Five Big Ideas in AI serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution, Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities, or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both online and offline that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendices. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the *Hands-On AI Projects for the Classroom* series
- A discussion entitled "What Is AI?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows:

Project Overview

The project overview offers an explanation of what the project is, how it ties to research-based standards, and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject, target grades, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, ISTE Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

Preparation provides the information educators need in order to put the project into action with students. This section includes a list of materials required for project completion; a list of supporting resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools, reviewing online resources, etc.

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.
- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject area content.
- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE. ISTE does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Glossary and Appendices

Glossary

The glossary includes definitions for terms found in the projects that may be unfamiliar or need explanation for students.

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in all four guides in the *Hands-On AI Projects for the Classroom* series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1

Programming With Machine Learning

Whether they realize it or not, machine learning is integrated into many of the applications students use every day. Powering tools from Netflix to autocorrect, this AI technology is used to quickly process data, personalize the user experience, and make tasks easier.

> This project would be great for expanding students' exposure to AI fundamentals in middle school CS courses. This project opens the door to have conversations around cultural bias in AI and the need for diversity in data sets. Especially considering incidents around racial inequity and injustices, stressing the importance of how AI is only as good as the data provided for machine learning is crucial. This emphasis would open the door to rich discussions and enable student cultural relevancy.
>
> —Susan Forget, STEM & PLTW Teacher, Sabin Middle School

Project Overview

In this project, students will learn what machine learning is and how it works. Then they will apply this knowledge to the development of a program that uses a machine learning model they have trained. In the process, they will see how useful machine learning can be to developing today's most effective software solutions.

SUBJECT

Computer science

ESTIMATED DURATION

6–8 hours

TARGET GRADES

6–12

PROJECT 1
Programming With Machine Learning

OBJECTIVES

At the end of the project, students will be able to:

- Train a machine learning model.
- Understand sources and implications of sampling bias in datasets.
- Use a machine learning model in the development of a software program.

VOCABULARY

artificial intelligence
bias
classification model
confidence level
data
dataset
decision tree
features
labels
machine learning
model
natural language understanding
sampling bias
supervised learning
test data
training data

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - c. Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
3. **Knowledge Constructor**
   - b. Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.
5. **Computational Thinker**
   - b. Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
   - d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.
7. **Global Collaborator**
   - b. Students use collaborative technologies to work with others, including peers, experts or community members, to examine issues and problems from multiple viewpoints.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.
3. **Collaborating Around Computing**
   - a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.
   - b. Apply effective teaching strategies to support student collaboration around computing, including pair programming, working in varying team roles, equitable workload distribution and project management.

Big Ideas of AI

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

CSTA K–12 Computer Science Standards

2-DA-08: Collect data using computational tools and transform the data to make it more useful and reliable.

2-DA-09: Refine computational models based on the data they have generated.

2-IC-20: Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21: Discuss issues of bias and accessibility in the design of existing technologies.

3A-AP-12: Create computational models that represent the relationships among different elements of data collected from a phenomenon or process.

3A-IC-25: Test and refine computational artifacts to reduce bias and equity deficits.

3A-IC-26: Demonstrate ways a given algorithm applies to problems across disciplines.

3B-AP-08: Describe how artificial intelligence drives many software and physical systems.

3B-AP-09: Implement an artificial intelligence algorithm to play a game against a human opponent or solve a problem.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Website: **Machine Learning for Kids**

SUPPORTING RESOURCES FOR EDUCATORS

- Application: "**Explaining Machine Learning with Decision Trees**"

ADVANCED PREPARATION

- Set up your class on the website **Machine Learning for Kids** (ML4K). For complete instructions for creating your free IBM Cloud account and ML4K teacher account, visit **ibm.org/activities/machine-learning-for-kids**. You may want to have students log into their accounts the day before beginning Activity 2 to confirm they can successfully access the platform.
- Set up a whole-class "Make Me Happy" ML4K project for Activity 3. We suggest you use the "whole-class project" feature of ML4K for this project so the entire class can contribute to the model and crowd-source the data. When you create the project, select the "Whole-class project?" option or, after you create the project, click the "Share" button to share it with the class. A video tutorial is available here: **twitter.com/MLforKids/status/1231578733288579072**
- Review the supporting materials for the "Titanic Survivors" and "Make Me Happy" ML4K projects.
  - "**Titanic Survivors**" Teacher Guidance Document
  - "**Titanic Survivors**" Student Worksheet
  - "**Make Me Happy**" Teacher Guidance Document
  - "**Make Me Happy**" Student Worksheet
- Select an ML4K project for your students' Culminating Performance.

Instructions

GETTING STARTED

Activity 1: Activating Prior Knowledge

In this activity, students will activate prior knowledge about **machine learning** by examining app functionalities they are likely familiar with, although they may not have considered how the tools work. The examples provided explore real-world scenarios that use machine learning to process various **data** types: text, numbers, images, and sound. If needed, students can do a quick search to learn more about the **AI** technology that powers them.

1. Provide students with a high-level introduction to machine learning. Emphasize that machine learning models can work with many types of data. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
2. For each of the real-world examples below, display and have students discuss the following questions in a small group; then share their answers with the whole class.
   - What is the purpose of this machine learning technology?
   - What type of data would the technology need to analyze to learn how to do that task?
   - What type of data does the technology collect to do the task for the user?
   - How do you think that machine learning technology works?

   Following are real-world examples of machine learning for small group discussion. Also included are optional extension questions for whole-group discussion.

   Text data. Predictive text in email, on smart devices, or during search queries. (Extend thinking: How does predictive text know what should come next? How does it learn your writing style? How does it know how to spell your last name?)

   Numeric data. Map apps that determine the shortest route by distance or time. (Extend thinking: How do map apps use numeric values to calculate time for travel? How do they know whether to allot more time for heavy traffic?)

   Image data. Facial recognition software used for social media tagging or unlocking smart phones. (Extend thinking: What type of facial features does the software use to recognize a specific person?)

   Sound data. A music recognition app, like Shazam, that tells you the title and artist of a song that is playing. (Extend thinking: What types of features is the app identifying in the song? If multiple artists have covered the same song, how would the AI know the difference?)

TAKE A CLOSER LOOK

Activity 2: Train a Machine Learning Model in Machine Learning for Kids

Machine Learning for Kids (ML4K) is a free tool, based on APIs from IBM Watson, that allows students to train and use machine learning models. In this activity, students will work as a class to create and discuss two models, one using a preexisting **dataset** and one using a dataset that the students create. Students do not need to build a programming project for this activity, but will instead focus on learning how to provide data to a machine learning model, train a model, and test a model.

> **NOTE:** The following walk-through asks students to consider reasons why people would or wouldn't survive the Titanic sinking. If you think this topic may be upsetting for students in your class, you can skip this example and teach the concepts of supervised learning, labels, features, models, decision trees, and confidence level through only the second model, "Make Me Happy".

1. Work through the "Titanic Survivors" project as a class. This project uses a provided dataset to develop a predictive machine learning model based on a decision tree.
   - Distribute or display the first 13 steps from the student worksheet for the "Titanic Survivors" project.
   - Walk through the first 9 steps together as a class. These steps set up an ML4K "Titanic Survivors" project template and display the training data set. Once the two labels ("survived" and "did_not_survive") and the data are displayed, use the visual to teach the following concepts:
     - This activity uses supervised learning to train a machine learning model to classify data. **Supervised learning** is a form of machine learning in which the trainer provides the AI with **labels** for each of the items in the training data. The AI then analyzes the data in each label group to identify patterns in the **features** (i.e., defining attributes) and creates a model.
     - In this case, the **model** will be represented by a **decision tree** that looks for each of the defining features that it identifies in the data. For example, a model for classifying animal data with the label "elephant" may identify features like four legs, large, floppy ears, and a trunk.
   - Have students analyze the training data provided and look for patterns. Then hold a class discussion using the questions provided in step 10 of the student worksheet.
   - Follow steps 11–12 to train and test the model on the "Learn & Test" page. The results provided predict whether a person with a certain set of characteristics would have survived or not survived the sinking of the Titanic as well as the AI's confidence level with that prediction. Explain that the **confidence level** is the probability that the item has been matched with the correct label.
   - Click on the "Describe your model!" button to see the machine learning model's decision tree. Ask students: Based on the information in the decision tree, what are the features in the model that are associated with the "survived" label? Which features are associated with the "did_not_survive" label?

2. Work through the "**Make Me Happy**" project as a class. The "Make Me Happy" project collects user-created data to create a classifier model that looks at whether a sentence is a compliment or an insult.
    - Prior to the lesson, be sure to set up and share a "whole-class project" version of "Make Me Happy" so that students can collaboratively contribute data from each of their individual accounts.
    - Walk through steps 7–10 of the "Make Me Happy" student worksheet together as a class. These steps open the project and add the labels "kind_things" and "mean_things" to the class project. Explain that this time you will be creating a classification model that will use **natural language understanding** to identify features to classify statements as compliments or insults.
    - Have students log in to their own accounts, open the class "Make Me Happy" project from their list of projects, and click *Train* to access the label buckets. Have each student add one sentence with an extremely nice compliment to the "kind_things" bucket and one sentence with a school-appropriate insult to the "mean_things" bucket. This will be the **training data** used to teach the AI model. Have each student add another compliment and insult to a collaborative document (digital, paper, or whiteboard), which will be used as **test data**. Once all of the data are collected, train the model, then test it with the list of test data to see how it performs. Let students know that you will discuss some reasons why a model might do a good or poor job at a task in the next activity.
    - Conclude this activity by having students explain how the "Make Me Happy" model works using the terms supervised learning, labels, features, models, decision trees, confidence level, classification model, training data, and test data.

Activity 3: Data and Sampling Bias

In this activity, students will consider ways that data sampling for training and testing data can affect the output of a machine learning model. Then they will return to the datasets for their "Make Me Happy" model and make improvements to refine the datasets.

1. Ask students: Are you happy with the way the "Make Me Happy" model performed? Was it always accurate? Could it have performed more accurately?
2. Tell students that an AI does not have opinions or thoughts of its own, but instead can only make decisions based on the data that it learns from. Because machine learning models learn from training data, the quality of the training data sample directly determines the quality of the model. **Sampling bias**, which would lead to an inaccurate model, is caused by having a dataset that does not accurately represent the labels. A quality dataset has the following characteristics:
    - Enough data: The AI needs enough examples to be able to identify patterns in the features of the data. The amount of data needed depends on the specific performance goal for accuracy at the task. The more accuracy needed, the more training data is needed.

- Accurate data: The AI needs to be given enough of the right types of examples to understand all of the correct features of items that should be accurately given a particular label. This means that if there are examples of that label that are missing or misleading, the AI will likely not identify those correctly in test data. Some examples of sampling bias include the following.
  - If you were training the AI to identify insects, but you only trained it on examples of ants and beetles, it would likely not be able to identify a praying mantis as an insect because some insect features would be missing from the data. Likewise, if the model will be used by many people in many countries, but insects from just one country are represented, the AI might not be able to recognize insects from other locations.
  - If you trained the AI using a data set in which all of the images of insects were taken in the grass but the images of non-insects were taken in a variety of places, the AI might identify the grass as a feature for the insect label. If the model was tested with an image of a dog in the grass, it might label it as an insect.
  - If there is a feature that could apply to both labels, but is only shown in one, that would mislead the AI. For example, if all of the non-insect training images were also of non-animals, then the AI could possibly mistake any animals with legs, heads, etc. as an insect when the model is tested.
  - If the training data includes significantly more examples of one label than another, then the AI might learn that it is more common and, therefore, incorrectly select that label more often.

3. Prompt your students to reflect on the collaborative experience of creating the "Make Me Happy" model. Ask students to identify the elements of the training and test datasets they created that worked well. Then ask them what types of things they could do to improve the model's results. Record and display their answers. Have students go back into their "Make Me Happy" project, make the dataset improvements they identified, and test the model to see if the results have improved. Have students continue to refine the dataset until the model is able to correctly identify sentences consistently and with a high degree of confidence.
4. *Optional:* Extend this learning activity by examining the four examples of machine learning tools in Activity 1 and discussing possible sources and impacts of sampling bias. You may even want to have students go one step further by researching current events that describe incidents where sampling bias led to negative outcomes in the use of machine learning models in applications. While this extension will reveal a downside of using machine learning in applications, the students should focus on the importance of avoiding sampling bias, and the role that people play in the outcome of the machine learning model.

CULMINATING PERFORMANCES

Activity 4: Programming with Machine Learning

To synthesize their learning from this project with other learning from their computer science course, students will use **pair programming** to complete an ML4K project in which they train and integrate a machine learning model into a Scratch, App Inventor, or Python program.

1. **ML4K** provides a variety of project worksheets with training and coding walk-throughs as well as corresponding datasets. Select and assign one or more ML4K supervised learning project options for your students to complete. Recommendations for beginner ML4K projects based on some common computer science course topics include: Cybersecurity—Face Lock; Data Science—Journey to School; Internet of Things—Smart Classroom; and Game Development—Snap!
2. When students have completed the programming portion of this activity, have them answer the following questions with their partner. Then discuss each of these questions as a whole class.
    - When testing your model, how well do you think the app performed? Why do you think that it performed well or not well?
    - What sampling biases did you identify in your dataset? What did you do to improve your dataset and the model's performance?
    - Do you think using a machine learning model made your program more useful or effective than programs that do not use machine learning? Why or why not?
    - What would be another type of program or solution that you could create using the same model you've already trained? How could you expand your model to work with multiple types of programs or solutions?

Activity 5: Reflect

In this activity, students discuss the following questions to reflect on their learning and consider the societal impact of using AI technologies in everyday applications.

- What are some consequences of using machine learning to power applications/apps?
- Now that you know more about machine learning and sampling bias, what questions would you ask yourself before trusting a machine learning tool, such as predictive text, facial recognition, or a product recommender?

Extensions

Here are two ways to expand students' experience in programming with machine learning:

1. Have students work individually or through pair programming to use an **iterative design process** to define a problem of their own to solve with a machine learning application. Students should collect and prepare a dataset; train a machine learning model in ML4K; integrate that model into an original program in Scratch, App Inventor, or Python; and discuss the ethical considerations and societal implications of their solution. For example, students might solve problems related to the COVID-19 global pandemic, such as:
   - An app that will turn on a light with voice command, so you can wash your hands without touching the switch.
   - A program that uses still images from a video to monitor how well people are practicing social distancing in public places: staying 6 feet apart and limiting the number of people in a gathering.
   - A program that analyzes the demographic and health information (age, height, weight, preexisting conditions, etc.) and COVID-19 symptoms of people who test positive for the virus to predict the likelihood that other people who contract the disease will display specific COVID-19 symptoms based on their specific demographic and health information.
2. Have students compare and contrast two machine learning systems. Train an image classifier model with a training dataset in ML4K as well as another machine learning image recognition system like **Teachable Machine** or Amazon Rekognition (accessible free through **AWS Educate**). Test each of the models with the same set of test images. Is one system easier to train than another? Do they produce the same outputs? Do they have the same confidence levels? Which system is the most accurate?

PROJECT 2

AI-Powered Players in Video Games

Games have provided a critical platform for the development of modern artificial intelligence dating back as early as 1949, when Claude Shannon calculated the number of branching moves in chess at 10^{120} and published "Programming a Computer for playing Chess" (1950). Because games are naturally engaging, problem-solving experiences, they are an ideal arena for explorations in AI and the power of computers to both solve problems and simulate a variety of behaviors. Even the simple AI integration in some of today's games can provide realistic bots and non-player characters for an improved user experience.

> Fred Rogers once said "Play is often talked about as if it were a relief from serious learning. But for children, play is serious learning. Play is really the work of childhood." The games students play now already use sophisticated and complex AI and will only continue to get better and more advanced as people study and work with AI systems. During the development of this project, we had a considerable amount of conversation about AI playing against human players, how the AI makes the game better, and how AI makes the playing the game more engaging. As teachers explore this project and this whole guide, I hope that they remember that "play is serious learning."
>
> — **Mark Gerl, Technology Teacher, The Galloway School**

Project Overview

In this project, students will explore how different AI algorithms are used to power or play various types of video games. They will examine the code of several simple games to see how computers play them and then improve their performance based upon their human opponents' choices. Finally, students will program an original game application with an AI character or object.

SUBJECT

Computer science

TARGET GRADES

9–12

PREREQUISITES

Basic coding skills, preferably with a text-based coding language.

ESTIMATED DURATION

5–8 hours

PROJECT 2
AI-Powered Players in Video Games

OBJECTIVES

At the end of the project, students will be able to:

- Explain common uses of AI in gaming.
- Implement an artificial intelligence algorithm to play a game against a human opponent.

VOCABULARY

artificial intelligence
behavior tree algorithm
bot
Finite State Machine (FSM) algorithm
Monte Carlo Tree Search (MCTS) algorithm
neural network
non-player character (NPC)
reinforcement learning

STANDARDS

ISTE Standards for Students

2. Digital Citizen

c. Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.

5. Computational Thinker

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

6. Creative Communicator

b. Students create original works or responsibly repurpose or remix digital resources into new creations.

ISTE Computational Thinking Competencies

4. Creativity & Design

d. Create CS and CT learning environments that value and encourage varied viewpoints, student agency, creativity, engagement, joy and fun.

5. Integrating Computational Thinking

c. Use a variety of instructional approaches to help students frame problems in ways that can be represented as computational steps or algorithms to be performed by a computer.

AI4K12 Five Big Ideas in AI

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.
4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

CSTA K-12 Computer Science Standards

3A-AP-15: Justify the selection of specific control structures when tradeoffs involve implementation, readability, and program performance, and explain the benefits and drawbacks of choices made.

3A-AP-16: Design and iteratively develop computational artifacts for practical intent, personal expression, or to address a societal issue by using events to initiate instructions.

3B-AP-09: Implement an artificial intelligence algorithm to play a game against a human opponent or solve a problem.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- *Optional:* Note cards and pens to support the iterative design process in the culminating experience.

SUPPORTING RESOURCES FOR EDUCATORS

- Book: ***Invent Your Own Computer Games with Python*, 4th Edition, chapter 10: Tic-Tac-Toe** and **chapter 15: The Reversegram Game**
- Article: "**10 Games That Have Successfully Integrated Artificial Intelligence**"
- Video Playlists: "**AI and Games**"
- Article: "**Reinforcement Learning**"

Instructions

GETTING STARTED

Activity 1: Activating Prior Knowledge

In this activity, students will hold a class discussion to activate prior knowledge about computer players in the games they play.

1. Hold a class discussion in which students consider the use of AI in games they currently play.
    - What games do you play that have a computer player, either when you play against the computer, or when you have computer characters as teammates or opponents? Do you think that computer player is powered by AI? Why or why not?
    - **Bots** are AI agents that can interact with computer systems or users. In video games, bots can be programmed to independently play a game or to compete as an opponent to, or a teammate for, a human player. **Non-player characters (NPC)** are characters or objects in a game that are not controlled by a human and do not play the game. AI is used to power the behaviors of many advanced NPCs. How do you think an AI playing relatively simple games (e.g., checkers, chess, or Starcraft II) is different from AI powering characters in video games (e.g., Madden NFL, FIFA, or World of Warcraft)? Do you think the AI would need different skills when playing a game against a human versus when simulating how a human (or game character) would act?
2. Share this artificial intelligence definition by software developer and author Al Sweigart[2] with students: "An artificial intelligence (AI) is a computer program that can intelligently respond to the player's moves" (2016). Ask students whether using this definition would change any of their answers as to whether characters in games would be considered AI. Then tell students that during this project they will learn more about the evolving role of AI in video games.

TAKE A CLOSER LOOK

Activity 2: Introduction to How AI Players Work in Games

In this activity, students consider various types of AI bots and NPCs, and why game developers would incorporate them into video games.

1. Have students watch the video "**AI Playing Games #12**" and read the article "**Artificial Intelligence in Video Games**." Each of these resources describes various uses of AI in games. As students watch and read, have them use a graphic organizer to write down what they learn about the four listed types of AI technologies used in video games. Key points may include:

2 Sweigart, A. (2017). Invent your own computer games with Python (4th ed.). San Francisco, CA: No Starch Press.

- A **Finite State Machine (FSM)** algorithm:
  - FSM is a relatively simple AI algorithm that works from a finite, specific list of all possible events a bot or NPC can experience in the game.
  - FSM is not optimal for every game, because it offers limited game challenges.
  - FSM is easy to outsmart, because it becomes repetitive.
- A **Monte Carlo Tree Search (MCTS)** algorithm:
  - In MCTS, the AI visualizes all possible bot moves, then based on those moves, considers what moves a human would make in response and what possible moves it could make in response to the human's move. After weighing the options, it makes the best choice.
  - MCTS is used in many strategy games.
  - Because visualizing the total number of options takes a lot of time and computing power, you can program the AI to pick from a smaller random number of choices to optimize speed.
- A **behavior tree** algorithm:
  - A behavior tree controls the flow of decision-making. It works by asking questions, starting with the first sequence node in a parent tree and moving through a series of sequential decisions; the leaves at the end of the branches are commands that tell the bot or NPC what to do. The AI player would continue to progress along the tree until it fails or doesn't meet a criteria, causing it to revert back to the original sequence node. When that sequence either succeeds or fails it returns the result to a parent node of all possible sequences.
  - A behavior tree allows a bot or NPC to respond to cues in the environment or to human player behaviors.
  - Complex behavior trees with cues to unlock new behaviors can create the illusion that the character is learning or adapting, even without the use of a neural network.
- A **neural network**:
  - A neural network processes information through a series of input nodes and hidden layer nodes to analyze the input and produce an output.
  - The neural networks that power bots and NPCs typically have a clear goal to achieve and are often given rewards or punishments as they attempt to achieve it (i.e., **reinforcement learning**). If the output achieves the desired goal, the AI succeeds and proceeds to the next goal in the game.

2. Discuss the 4 types of AI technologies that have led to new evolutions in more complex games.
   - What do all of these types of AI technologies have in common? Possible answer: In all types, an AI makes decisions based on certain cues or conditions, not randomly.

- How do FSM, MCTS, and behavior trees differ from neural networks? Possible answer: An AI that uses FSM, MCTS, and behavior trees makes decisions based on choices or paths that have been provided to it. An AI that uses neural networks/machine learning can be trained to get better at tasks over time and may even complete tasks in ways that the trainers did not imagine.
- How does the use of each of these technologies for the AI affect the complexity of the bot or NPC in the game? Possible answer: FSM is the most simple; characters can only do a few things. With time, MCTS can process billions or trillions of possible play paths and make the best possible choice. Behavior trees allow for the illusion of learning from the player, giving a more realistic experience. Neural networks allow for the greatest possibility of complexity and realism, but also take the most effort to train to act in desired ways.

3. After the students have identified the characteristics of these four types of AI in games, have them work in small groups to identify or research examples of AI-powered bots or NPCs that are examples of all four types. Possible answers include:
   - FSM-powered bots or characters: ghosts from Pac-Man; demons from DOOM; creepers, zombies, and spiders in Minecraft; gym leaders in Pokemon.
   - MCTS-powered bots or characters: computer players in digital chess, poker, Go, or Civilization.
   - Behavior tree-powered bots or characters: NPCs in World of Warcraft or EverQuest; aliens in Alien: Isolation; computer players in Halo 2, Far Cry 4, and BioShock Infinite.
   - Neural network-powered bots or characters: TD-gammon; DeepMind's AlphaStar playing StarCraft II; IBM Watson playing Jeopardy; Mar-IO playing the game Super Mario Brothers.

   > **NOTE:** Neural network-powered bots or characters are not yet common as the data that needs to be collected and analyzed for thousands or millions of AI players would be massive, but that may not be a restriction in the future as cloud processing and storage becomes faster and cheaper.

4. *Optional:* Let students know that the use of AI in games is rapidly advancing. Break students into small groups and have each group perform a quick research activity to find 5–10 facts about one of the topics below that reveals emerging uses of AI in video games. Then have groups share what they learned.
   - AI bots that use machine learning to emulate human play styles, such as FIFA or Madden games (possible resource: "**AI for FIFA and Madden Games Is about to Get a Whole Lot Better**,")
   - AI bots that use machine learning to get better at the game by actively learning from its human players (possible resource: **QuickDraw**)
   - Curiosity-driven AI bots like the one that plays Super Mario Brothers (possible resource: "**Curiosity-Driven Learning: AI agents exploring without looking at any scores**")
   - Any other AI-powered bot or NPC topics of your choosing

Activity 3: Developing an AI Computer Player

In this activity, students will take their conceptual knowledge about how humans play games and start to think about how a program could be written to have a computer play a game intelligently. In the process, students will examine two programs written in Python. Even if Python is not their standard coding language, students with background knowledge in basic coding skills and text-based languages should be able to understand the simple commands and comments provided.

1. Have students play 10 rounds of Rock Paper Scissors against each other. Discuss: As humans, how do you play the game? Were your choices always random? Did they go in a pattern? Did you try to adapt to what the other player did? As you played longer, did you change your strategy for playing?
2. Tell students that in this activity, they will be writing and improving a pseudocode program for a computer player to play Rock Paper Scissors.
    - Have student pairs use natural language pseudocode to write a program for a computer player to play Rock Paper Scissors against a human player.
    - Next have students play at least 10 rounds of **Rock Paper Scissors, Version 1** against a computer using Trinket.io. Tell them to review the provided Python code and think about how it compares to the pseudocode they wrote. Ask:
        - How is the computer player choosing what move to play? Possible answer: It's not really "choosing;" it's just generating a random selection from line 15 and 16.
        - What is the computer's strategy for how to win? Possible answer: There is no strategy. Winning is pure luck.
        - Is this an example of artificial intelligence? Possible answer: No, because there is no autonomous, perception-based decision making. The computer player does not respond intelligently to the human player's moves.
    - Then have students play at least 10 rounds of **Rock Paper Scissors, Version 2** against a computer using Trinket.io. Tell them to review the provided Python code and think about how it compares to both the pseudocode they wrote and the first Rock Paper Scissors code they reviewed.
        - How is this computer player choosing what to play? Possible answer: First, at random. Then, after 5 rounds of play, lines 29–44 identify the human player's most-played moves. The computer chooses the move to beat that move (e.g, if the human player throws rock most, then the AI will throw paper).
        - What is the computer's strategy for winning? Possible answer: Assuming humans subconsciously throw a "favorite" move more often; the computer throws the move that will beat that move more often.
        - Is this an example of artificial intelligence? Possible answer: Using Al Sweigart's definition, we can say that this program demonstrates a simple AI, since the computer player tracks and responds to the human player's most often played moves. As the human player adjusts their play style, the computer player adapts as well.

- What data need to be collected to defeat a human player? Where is it in the code? Possible answer: Lines 14 and 15 build an array of moves, and lines 16–18 count the number and type of moves.
- Is this the only way to have a computer player respond intelligently to a human player in Rock Paper Scissors? Possible answer: No, other options include tracking the moves of all players to improve response; tracking play of the best player and simulating him/her; identifying patterns in how humans select their moves.
- What data need to be collected for a computer to simulate a specific human player? Possible answer: To simulate a person, the computer player would need to collect more rounds of play and look for patterns as well as counts. It would need to save tracking data for many games to an external file or database with a human player identifier.

- Allow student pairs time to improve their pseudocode games to make sure their computer player intelligently responds to the human player. Have pairs compare and contrast their final approach with another pair. Discuss the various ways students came up with to have a computer player intelligently play Rock Paper Scissors, including which is most human-like.

Activity 4: Programming AI for Computer Players

In this activity, students will look at two other simple—but more complex than Rock Paper Scissors—games played by a computer player. The code for these two programs comes from Al Sweigart's book *Invent Your Own Computer Games with Python*, 4th Edition (2017). In this activity, students should be thinking about how the simple AI is programmed and what type of AI game approach is used: FSM, MCTS, behavior tree, or neural network. Depending on the students' experience, the size of the class, and the amount of time you have, students can complete one or both of these options as individuals, small groups, or as a whole class. Again, while these programs are written in Python, students with background knowledge in basic coding skills and text-based languages should be able to understand the simple commands and comments provided.

1. Have students play **Tic-Tac-Toe** against a computer using Trinket.io. Have them read through the code, and then direct students to examine lines 90–117 to see how the computer player's AI is programmed.
   - How is the computer player choosing what to play? Possible answer: The computer is using a decision tree about the current state of the board. Based on the state (sequentially: if it can win the game on that turn, if the opponent can win, or if the corners, center, or sides are free), it makes a move.
   - What is the computer's strategy for playing? Possible answer: If it can't win the game on that turn, it will block the opponent from getting three in a row, or pick the best available space.
   - What type of algorithm is used to program the AI? Possible answer: A simple FSM algorithm.

2. Have students play **Reversegram** (a version of Reversi or Othello) against a computer using Trinket.io. Direct students to examine lines 162–82 to see how the computer player's AI is programmed.
    - How is this program choosing what to play? Possible answer: Lines 162–82 are the decision trees the computer uses to determine which moves will result in the highest number of flips.
    - What is the strategy for playing? Possible answer: The first strategy is to capture a corner (168–71); the next is to select moves that have the highest resulting flips (174–82).
    - What type of algorithm is used to program the AI? Possible answer: This is a simple Monte Carlo Tree Search, branching optimal moves out of all possible moves.

Activity 5: AI in Games and User Experience

In this activity, students will consider how the design of AI-powered bots and NPCs affects the user experience.

1. Discuss the following as a class using a cooperative learning structure, such as **numbered heads together** or **think-pair-share**.
    - How do you feel playing against a computer versus playing against a person? Does it matter if you know whether you are playing against a computer or a person?
    - Do you think that users would rather play against an AI-powered bot that is portrayed as a human character versus as a robot or other nonhuman character?
    - If you didn't know you were playing against an AI, what clues might tell you that the opponent was an AI?
    - If the AI were always to win, would you think it is a well-designed AI player? Why or why not? If not, how might you approach better designing that AI player?
    - How can you use what you've learned from looking at these programs to improve the design of computer-controlled characters and objects in your own games?

CULMINATING PERFORMANCES

Activity 6: Programming a Game With an AI Bot

In this activity, student pairs will use an **iterative design** process to write a game program in which a computer player will play against a human player. While the programs they examined in this project were in Python, they can write this program in any language they work with in class.

> **NOTE:** If this project is implemented in an AP Computer Science course, consider adding additional program requirements, such as the use of a list, a procedure, or an algorithm with multiple control structures.

1. Direct students to use an iterative design process to program a game in which a computer player plays against a human player. Students can remix the code from any of the four programs provided in this project or create a fully original program. If students use any code that was written by someone else, they must provide appropriate acknowledgement through citation or attribution. Some ideas for this game include:
    - Write to expand on Rock Paper Scissors or Tic-Tac-Toe by changing the complexity of the game (e.g., extra hand signs in Rock Paper Scissors, or a larger board in Tic-Tac-Toe), or by changing the way that the computer player adapts to the human player's moves.
    - Write to have an AI play more aggressively or more defensively.
    - Write to increase or decrease the AI's win-loss ratio so that the human can choose an easy or hard level of difficulty.
    - Write two AIs that can play against humans or each other.
    - Write to simulate your personal play style and match your average win-loss ratio.
    - Write to simulate someone else's play style and match their average win-loss ratio.
2. Once students have completed their programs, hold a gallery walk in which students have time to play others' games and provide peer feedback on the user experience, including something they like and something they might improve.

Activity 7: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the personal and societal impact of AI in games:

- What do you see as the most powerful or game-changing effect of integrating AI into bot and NPC development and behavior?
- Do you think that gaming environments will eventually have AI-powered characters that are so realistic that you don't know whether it is a human or AI? Why or why not?
- Where do you see the future of AI-powered bots and NPCs in video games going?

Extensions

Following are four ways to expand students' exploration of AI-powered players in video games.

1. Students can learn more about writing games with AI in Python through Al Sweigart's books, *Invent Your Own Computer Games with Python*, 4th Edition, and *Making Games with Python & Pygame*, which are available to read for free on his website, **inventwithpython.com**.

2. Students can learn more about the use of neural networks and reinforcement learning to train AI players by watching the "**Let's Make an AI that Destroys Video Games (LAB) #13**". They can take that learning even further by completing the corresponding **hands-on lab**. Both of these resources walk students through the process of reinforcement machine learning and its application for developing quality AI players.
3. Self-motivated students who want to learn more may want to explore the user-developed artificial intelligence game development tutorials available from **GameDev.net**.
4. Students who have taken Advanced Placement math and computer science courses may want to explore the use of AI within an industry tool through **Unity's online course for beginners**.

> I'm excited about this project because it is very comprehensive and deals with AI in video games, which grabs the attention of the students. I plan to work through all of the resources and programs myself ahead of time and get familiar with the content before assigning it as a project.
>
> — Leah Aiwohi, Computer Science & Media Arts Teacher, Kauai High School

PROJECT 3

Using AI for Robotic Motion Planning

Ask the average person about AI and they will likely mention robots. In fact, many may even voice misconceptions that all robots are AI or that AI technology is the same as robotics.

> AI is one of many rapidly evolving technologies—from drones, to smart cars, to automated machines used in manufacturing. This AI project empowers students to thrive as critical thinkers, problem-solvers, and innovators as they build a solid foundation in AI and robotics.
>
> — David Lockett, STEM & IT Teacher, Bok Academy

Project Overview

In the light of the above, this project aims to help students distinguish between AI-powered robots and simple automation, and to expose students to the functions and capabilities that are typically unique to AI-powered robots. Students will explore these ideas through discussions, research, and simulations, and then apply their new knowledge to consider a real-world problem and develop a small-scale simulation of an AI robotics solution.

SUBJECT

Computer science and robotics classes.

TARGET GRADES

8–12

PREREQUISITES

Basic coding skills

ESTIMATED DURATION

8–12 hours

OBJECTIVES

At the end of the project, students will be able to:

- Discern between robots that do and do not have AI capabilities.
- Explain how AI-powered robots use perception and reasoning for motion planning.
- Examine fundamental ethical considerations related to AI and robotic motion planning.

VOCABULARY

artificial intelligence (AI)
AI agent
artificially intelligent robot
autonomous
ethical
machine learning
motion planning algorithm
neural network
robot
sensor
sensor fusion
sequential decision-making

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
4. **Innovative Designer**
   - a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
   - c. Students develop, test and refine prototypes as part of a cyclical design process.
5. **Computational Thinker**
   - d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.
2. **Equity Leader**
   - b. Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.
4. **Creativity & Design**
   - c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.
4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

CSTA K–12 Computer Science Standards

2-CS-02: Design projects that combine hardware and software components to collect and exchange data.

2-IC-2: Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

3A-AP-13: Create prototypes that use algorithms to solve computational problems by leveraging prior student knowledge and personal interests.

3A-IC-2: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.

3B-AP-08: Describe how artificial intelligence drives many software and physical systems.

3B-AP-09: Implement an artificial intelligence algorithm to play a game against a human opponent or solve a problem.

Preparation

MATERIALS

- One or more AI-powered robots, such as Cozmo, Zumi, GoPiGo with Google Cloud Vision API, AutoAuto, or Little Sophia.
- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Tool: CarLab

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "What's the Difference Between Robotics and Artificial Intelligence"
- Article: "How Robots Work: Robots and Artificial Intelligence"
- Article: "Why Sensor Fusion is the Key to Self-Driving Cars"
- Article: "From Computational Thinking to Computational Action"

ADVANCED PREPARATION

- Learn about the sensors and motion-planning functionality of the AI-powered robot you will be using with your class.
- Experiment with the CarLab simulation and review steps 5–9 in Activity 3.

Instructions

GETTING STARTED

Activity 1: The Characteristics of an AI Robot

In this activity, students will activate prior knowledge as they consider different types of robots and identify the characteristics that distinguish an **AI robot**.

1. Ask students to list robots that they have used themselves or seen in the news or popular media. If some of the robots they mention are fictional, have them label them as such.
2. Tell students that some robots have artificial intelligence while others do not. Give them the criteria below to evaluate each robot on their list. If students need help, let them know that if a robot does have AI capabilities, you may be able to tell because it can do things like: recognize specific objects or faces, navigate around objects on its own, classify or distinguish between objects, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the **autonomous** decisions made by AI are more advanced than the simple automation of a task (performed in a prescribed sequence of steps), which non-AI robots are frequently used for.
   - Criteria 1: An AI robot must be able to perceive the world around it.
   - Criteria 2: An AI robot must be able to analyze and organize the data it perceives.
   - Criteria 3: An AI robot must be able to reason and make autonomous decisions based on data it perceives.

TAKE A CLOSER LOOK

Activity 2: Sensors—How Do Robots Perceive and Understand

Sensors allow AI-powered robots to perceive the natural world. In this activity, students will research common sensors used in robotic systems. Then they will examine the class's AI-powered robot to identify its sensors and capabilities.

1. An AI-powered robot uses **sensors** to perceive the world around it. Distribute a graphic organizer or have each student create a table to support their research of robot sensors. The graphic organizer should include three topics: the name of the sensor, the data that the sensor perceives, and how an AI-powered robot might be able to use that data. Using a jigsaw instructional strategy, assign one or more unique robot sensors, such as lidar, contact or touch sensors, or barometers, to each individual or small group. Have students research their assigned sensors and record their findings in their table. For example, ultrasonic sensors measure the distance to a target using reflected high frequency sound waves. This sensor's data can be used by an AI-powered

robot to determine that an object has passed in front of it and how far away the object is. Once students have completed their research, have them report their findings to the whole class. They should also add information garnered from other students' presentations to their tables. At the end of the activity, all students will have information about each of the sensors researched.

2. Next, have students complete a robot scavenger hunt to examine the hardware, software, and documentation for the AI-powered robotics platform they are using in your classroom and identify the sensors available. For each sensor, have students identify the name of the sensor, the data the sensor collects, and how the data is represented by the robot for the user to see. For example, a table for **Zumi the Robot Car** might look like this:

Sensor	Data	Data Representation For the User
Pi Camera	Visual data. The computer processes it as pixels but displays it in the form of images and video.	Saved on the computer (Raspberry Pi Zero board) as a .jpg file and can be opened in any image file application.
Gyroscope	Rotational motion (how much it is turning) as numeric angles for the x, y, and z axis.	Use update_angles() function to get angles for x, y, and z axis. Angle values range from 1 to 360.
Accelerometer	Acceleration values for each axis to find Zumi's orientation with respect to the strongest force being applied to Zumi (gravity).	Use get_orientation() function to get orientation state value: –1 = unknown 0 = probably falling or moving between states 1 = camera straight up 2 = camera facing down 3 = on right side 4 = on left side 5 = wheels on floor 6 = wheels facing up (upside down) 7 = accelerating faster than 1g
6 IR Sensors	Distance values to a target using reflecting infrared light waves. Sensors are in the front right, bottom right, back right, bottom left, back left, and front left.	Use get_IR_data() function to get one of the 6 sensor values which range from a value between 0 and 255.

3. As students complete these activities, they may notice there are different types of sensors that accomplish the same task, such as detecting the distance from the robot to an object. Ask students why they think there are different types of sensors used to accomplish the same task. Possible answer: Many different sensors are used to collect the same data to create a system of redundancy and to increase accuracy. When data are collected from multiple sources, it is more reliable. Instead of assuming the ultrasonic sensor is reading an accurate distance, you can compare the value with an infrared (IR) sensor to ensure its accuracy. Changing conditions (like weather) can also affect certain sensor values. The more redundancy of measurement, the more reliable the system. Some sensors also measure data differently. Lidar and cameras can both detect objects. Lidar can see how far away something is and its general shape, but cannot see finer details like color and other two-dimensional details. Cameras can see an object's general shape and all the finer details (color, writing, etc.), but do not know how far away objects are. Robotic systems like self-driving cars combine these two sensors to create a better system for object detection. The ability of an AI to combine perception from multiple sensors into one model is called **sensor fusion**.
4. Finally, have students select one of the robot's sensors and describe one way the data perceived can be used to accomplish a task with AI. Possible answer: AI can be used with the camera's image data to detect objects and determine the difference between those objects; it can differentiate between pedestrians, cyclists, and other cars on the road, for example.

Activity 3: Self-Driving Car Simulation—Motion Planning and Obstacle Avoidance

In this activity, students will interact with an AI-powered self-driving car simulator to understand how an AI represents and reasons about the information it perceives.

1. A self-driving car is an example of an AI robot. Ideally, self-driving cars would be able to perceive the world around them and navigate roads safely with little or no human input.
2. Project one or both of the following videos that show both a camera view and the AI representation of the Cruise autonomous vehicle navigating in difficult scenarios involving emergency vehicles, bicycles, and pedestrians: "**Watch Cruise Self-Driving Car Maneuver Around Emergency Vehicles in San Francisco**," and "**Watch a Self-Driving Car Safely Maneuver Around Cyclists and Scooters in San Francisco**." Ask students what they observe about the sensors, perception, and navigation in the videos. Point out to students that it isn't enough for the autonomous vehicle to perceive with sensors; it has to be able to interpret and represent that perception, as well as reason, to decide how to act on what it perceives. Tell students that in this activity they will learn more about AI representation and reasoning.
3. Run and project the **CarLab** self-driving car simulator for the students to see. Explain the following:
    - CarLab is a simulator that allows the user to train a self-driving car's **neural networks** to safely navigate a track by avoiding walls and other vehicles. In the simulator, the self-driving car–called Network Car–is represented as a sports car. There are several smaller cars simultaneously driving on the track that the user cannot control or program.

- For an AI to make a decision with the information it perceives, it needs to collect data, represent the data, and reason about the best next action to take. Self-driving cars collect a variety of data via sensors and process the data through several algorithms that control various aspects of decision-making. In this activity, students will consider the perception, representation, and reasoning needed for a car's **motion planning algorithm**. A motion planning algorithm is a form of **sequential decision-making** in robotics to support movement and navigation from one point to another. In motion planning, robots reason to make a series of small decisions about what to move and where to go in order to safely navigate or perform other tasks.

4. Ask students: What data would a car's motion-planning algorithm need to perceive, represent, and reason about? What types of sensors would gather those data?
   - *Possible answer:* The car's motion-planning algorithm will receive input from cameras, lidar, and other sensors about where the lanes and other cars are located. It will then use sensor fusion to combine those input data, which are represented as an occupancy grid showing the free space around the vehicle.
5. Direct students to open the CarLab self-driving car simulator. Walk students through the following steps to create their own copy of the simulator.
   - Click the "Fork" button at the top of the repl.it programming environment to create a copy.
   - Click the "Run" button at the top of the repl.it programming environment to run the program.
   - Right-click on the "Car View" window's title bar and select "Layer" then "Top," shown in Figure 2.
   - Right-click the "GridWorld" window's title bar and select "Maximize," shown in Figure 3.
   - When properly launched, the simulator should resemble Figure 4. If at any point students make a mistake during any of the steps above, they can reload the link and start over.

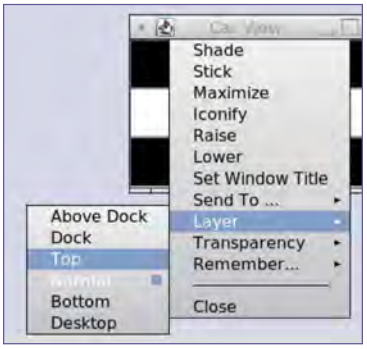

FIGURE 2. Arrange CarView window in CarLab simulator.

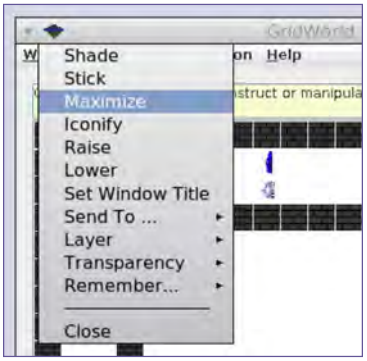

FIGURE 3. Maximize GridWorld window in CarLab simulator.

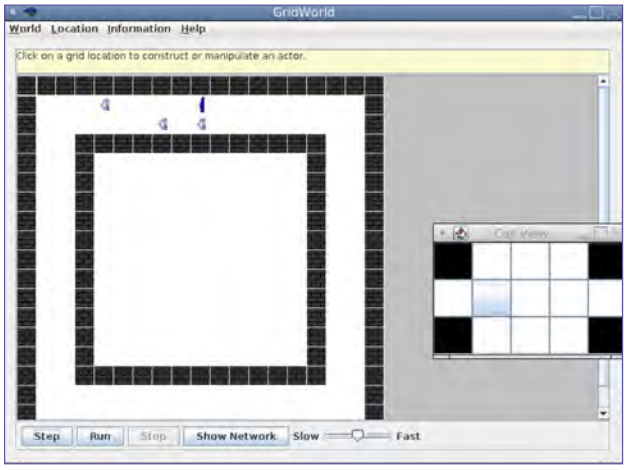

FIGURE 4. CarLab simulator window view.

6. Help students make a connection between the answers they provided in the previous discussion and the CarLab simulation. Explain to students how the self-driving car in the simulator represents the data it perceives:

   - The Network Car's perception data are represented in this simulator as a Car View occupancy grid. The grid displays the car's location as a gray cell. The other cells depict the car's perception of the lanes on each side as well as its own lane ahead and behind. Unoccupied cells are represented in white; occupied cells are represented in red; and cells that are outside the car's view are represented in black. An example is shown in Figure 5.

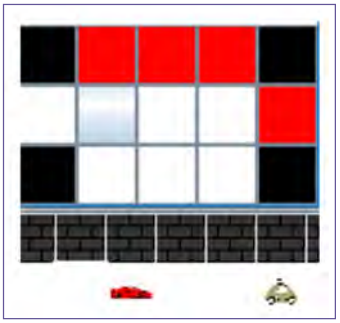

FIGURE 5. Car View occupancy grid in CarLab simulator.

   - Direct students to click the "Run" button beneath the track (inside the GridWorld window) to see how the occupancy grid changes when the Network Car is driving. Then, have students click the "Step" button to see how the occupancy grid changes step-by-step as the Network Car navigates the track. In each step, help students describe what the occupancy grid is depicting and identify whether a wall or car is in each occupied cell.

7. Tell students they will next examine and train the neural networks that make up the Network Car's motion planning algorithm.

   - The Network Car's motion planning algorithm uses **machine learning** to determine how to move and avoid obstacles in various situations. The three neural networks analyze the provided training data to identify patterns and create a machine learning model that it can use to determine when to move forward, when to turn, and when to change lanes. If students need more background information on how machine learning works, supporting resources can be found in **Appendix A: Unpacking Artificial Intelligence**.

   - Direct students to the NetworkCarTrainer.java file in the left hand Files panel. NetworkCarTrainer is the only file they will be editing in this activity. The three neural networks that CarLab uses to support the Network Car's motion planning algorithm appear in the program as Turning Network, Forward Network, and Lane Change Network. In the previous step, students may have noticed that the Network Car only drives around in a tiny circle. This is happening because, while all of the networks have been provided with some starter data, only the Forward Network–which tells the car when it is safe to drive forward–has been given enough training data to successfully navigate the track. In this activity, students provide the Turning Network and the Lane Change Network with additional training data so that the Network Car will navigate the track more successfully.

   - The neural networks in CarLab use training data that consists of three dimensional arrays. Students edit data in the inner two arrays. Each pair of inner arrays is a single training sample that represents a specific scenario. For example, in forwardData, the first array represents the three cells directly in front of the car. A 0 indicates the cell is unoccupied; a 1 indicates the cell is occupied. The second array indicates the target output of the network, whether the car should move forward. A 0 indicates the car should move forward; a 1 indicates it should not. For example, in the scenario in which a small car is located three cells ahead, the Network Car should move forward ({{0,0,1},{0}}), but in the two scenarios where a small car is located in either of the next two cells, the Network Car is told not to move forward ({{1,0,0},{1}} and {{0,1,1},{1}}).

The neural network learns from this training dataset that it is only safe for the Network Car to move forward when there are two open cells between it and the car in front of it.

8. *Training the Turning Network:* To train the Turning Network, students enter turnData representing the occupancy of the grid and whether the car should turn.

   - When editing the two inner arrays, the first array in turnData represents locations in the occupancy grid. Indexes for each training sample are in order from the left side of the car, in front of the car, and the right side of the car, as shown in Figure 6. A 1 indicates the cell is occupied; a 0 indicates the cell is unoccupied. For example, the scenario depicted in Figure 6 would be represented by the array {1,1,1,0,0,1,0,0,0}. The second array that represents the target output of the network, whether the Network Car should turn, uses a 0 to indicate that it should turn and a 1 to indicate that it should not turn. Given the scenario in Figure 6, the car should not turn; therefore, the second array should read {1}. The full three dimensional array for this training scenario would be {{1,1,1,0,0,1,0,0,0},{1}}.

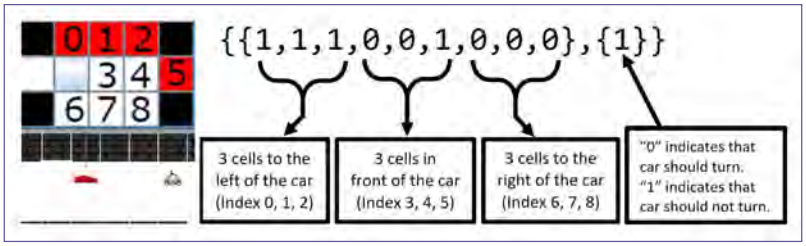

FIGURE 6. Editing TurnData arrays in CarLab simulator.

   - If students were programming a car without machine learning, they would need to provide it with all 512 (i.e. 2^9) possible scenarios the car could encounter and what movement it should make. With machine learning, students can train the Network Car to know when to turn with approximately 20–25 pieces of training data that represent a variety of possible scenarios.
   - Direct students to the NetworkCarTrainer.java file, where they can see the TurnData dataset. Currently the Network Car is trained on three data points in lines 7–9. The code includes another 17 data points that can be used for training data, but are currently commented out in lines 10–27.
   - Have students add training data to the Turning Network by deleting the two backslashes (//) at the start of each commented line. They can choose to use some of the data provided, all of the data provided, or even add additional data of their own. Each time students change the training data, they will need to rerun the entire program to see the changes in the way the Network Car drives. Students can do this by following a process similar to the one they used at the start of the activity: clicking the "Run" button at the top of the programming environment, right-clicking on the "Car View" window's title bar and selecting "Layer" then "Top," and right-clicking the "GridWorld" window's title bar and selecting "Maximize." Then, they can click the "Run" button beneath the track (inside the GridWorld window) to start the self-driving car simulation. Students should make changes until the Network Car only turns when it can do so safely. The Network Car may still crash because it needs to change lanes, but they will address this next.

- As students adjust the training data, have them observe the changes, then discuss as a class how the additional training data changed the way the car drives.

9. *Training the Lane Change Network:* Next, students will train the Lane Change Network. This self-driving car simulator is programmed so that when the Network Car is driving in any cell, if the Network Car is told not to turn and not to drive forward, it will then check to see if it needs to change lanes to the left or to the right.
   - In the real world, self-driving cars must not only make decisions about which direction to drive in, but also how to avoid obstacles. Have students add 3–5 rock obstacles to their track. To add rocks, students click on the track and select info.gridworld.actor.Rock(). The Network Car must be able to respond to these situations without crashing or driving in circles. Have students test their car to see how successfully it is able to navigate the track with added obstacles.
   - The Network Car needs to learn to change lanes appropriately to successfully avoid cars and other obstacles. Have students examine the track and the occupancy grid. Ask: Of the cells in the occupancy grid, which cells' data would the Network Car need to perceive and reason with in order to know if it should change lanes to the left? To the right? Have students justify their responses with specific scenarios about the location of walls and cars using those data.
   - Explain that this particular Lane Change Network determines whether the Network Car can safely change to the left or right lane by evaluating the status of the three cells to that side, perceiving whether or not they are occupied, and deciding if it is safe to move there. For example, to decide if it will change lanes to the left, the Network Car will analyze the status of the cell directly to its left, the cell it would move into (diagonally to the front left), and the cell in front of the cell it would move into to determine if those cells are occupied. These cells are represented by indexes 0, 1, and 2 in Figure 6. Since the network does not distinguish between walls, rocks, or small cars, the scenarios presented in the training data must account for an occupied space being occupied by any static or moving object. The Lane Change Network then mirrors this process when making a decision about changing lanes to the right.
   - Have students create their own training laneChangeData for the Lane Change Network using the three dimensional array format {{x,x,x},{x}}. The indexes of the first inner array represent the occupancy of the three cells on the side the network is analyzing. A 1 indicates the cell is occupied; a 0 indicates the cell is unoccupied. The second inner array that represents the target output of the network, whether the Network Car should change lanes, uses a 0 to indicate that it should change lanes and a 1 to indicate that it should not. There are 2^3, or 8, possible occupancy combinations. One piece of training data is already provided: {{0,0,0},{0}}, which states that if all of the cells to that side are unoccupied, then it is safe to change lanes. Students should enter no more than five additional training scenarios to try to get the Network Car to successfully decide when to change lanes.
   - Each time students change the training data, they will need to rerun the entire program to see changes in the way the Network Car drives. Students can do this by following a process similar to the one they used at the start of the activity: clicking the "Run" button at the top of the programming environment, right-clicking on the "Car View" window's title bar and selecting "Layer" then Top," and right-clicking the "GridWorld" window's title bar and selecting "Maximize." Then, they can click the "Run" button beneath the track (inside the GridWorld window) to start the self-driving car simulation. Students should make

changes until the Network Car only changes lanes when it can do so safely. Have students test their own Network Car with obstacles and other small cars, and iterate to improve the training data to get it to drive as successfully as possible.

10. Have students test each other's motion planning algorithms by adding new rock obstacles to the course and observing how well the Network Car is able to navigate the track. Have students provide peer feedback about what did and didn't work well, then iterate upon their data to improve the models as needed.

11. Conclude this activity with a class discussion.

    - This simulation defines safe driving as not crashing while traveling around the track. How much data did the car need to safely navigate the track? What might be the effect of having too little data? What might be the effect of having too much data? What other criteria for safe driving might a motion planning algorithm need to account for to be considered successful?
    - How does using machine learning for motion planning improve navigation for self-driving cars?
    - Based on your experience with this activity, what issues with perception and motion planning might arise in the development of AI-powered robots of various kinds?

Activity 4: Ethics Around AI Motion Planning

In this activity, students will consider **ethical** questions that surround allowing robots to make autonomous decisions.

> **NOTE:** This activity asks students to consider tough decisions about the behavior of self-driving cars when encountering life-threatening scenarios. If you think this topic may be upsetting for students in your class, you may want to skip the Moral Machine simulation or the Ethics Around AI Motion Planning activity.

1. To introduce the topic, project the video "**The ethical dilemma of self-driving cars–Patrick Lin**." Then discuss the following as a class.

    - In the situation described, would you prioritize your safety over everyone else's by hitting the motorcycle? Would you minimize danger to others by not swerving, even if you would hit the large object and potentially die? Would you take the middle ground by hitting the SUV since it's less likely the driver will be injured?
    - In comparison to what you would do, what should a self-driving car do? Think about if you were the motorcyclist or the SUV driver.
    - What is the difference between a "reaction" (human driver's split-second response) and a "deliberate decision" (driverless car's calculated response)?
    - Programming a car to react in a certain way in an emergency situation could be viewed as premeditated homicide. Do you think this is a valid argument? Why or why not?

2. Direct students to imagine that they are hired to help program the navigation rules for a new self-driving car. Ask them what rules they might consider giving the car. Then introduce them to the activity **Moral Machine**, which is a platform for public participation in and discussion of the human perspective on machine-made

moral decisions. When students click the red "Start Judging" button, they will be given 13 randomly selected scenarios to evaluate and respond to. After completing all 13 scenarios, students can review their results and how their responses compare to others who have participated in the simulation. Wrap up the activity by discussing the following as a class.

- The Moral Machine simulation represents one way that engineers could train AI robots to make decisions—by crowdsourcing the public's decisions and having the AI act accordingly. What do you think would be the pros and cons of that method of decision-making? What would happen if people responded in ways that negatively affect some groups of people more than others? What might be other ways to train an AI to make these tough decisions?
- How does it make you feel to know an AI might be making these decisions instead of a human? If you found out that having an AI make these decisions resulted in safer roads and workplace environments, would that change your opinion?

CULMINATING PERFORMANCES

Activity 5: Programming an AI-Powered Robot

In this culminating performance, students will work in pairs or small groups, using an **iterative design process**, to define a problem that can be solved with an AI-powered robot. They will develop a small-scale simulation of the solution with the class robot.

1. Tell students that they will work in pairs or small groups to develop an AI-powered robotic solution to a real-world problem.
2. Direct students to brainstorm, research, and define a problem that might be solved with an AI-powered robot. For example, a sheep farmer may want an alternative to using sheepdogs to herd sheep, or a student may want an automated way to refill his or her water bottle during class. Ideally, students should identify a problem in their own home, school, or community.
3. Have students develop a solution that uses sensors for perception and involves a motion planning algorithm for navigation. For example, a robot sheepdog might gather stray sheep, or a robot server might notice that your water bottle is empty and quietly refill it.
4. Using the class AI-powered robot, students will develop a small scale simulation as a prototype of the solution, then test and iterate their solution. As part of the prototype, they should be able to describe what role the AI plays in their solution. For example, if your students are using a **Cozmo** robot:
   - A robot sheepdog might collect blocks representing sheep and bring them all to one location representing a sheep pen. The AI would perform visual recognition to identify whether a particular block is or is not a sheep as well as motion planning to navigate around the map and avoid obstacles.
   - A robot server might perceive that a block representing a water bottle is turned on a particular side to convey it is empty, retrieve the block, take it to a filling station, execute a movement there, and return the block to where it came from. The AI would perform visual recognition to discern between full and empty bottles as well as motion planning to remember the original location of the bottle, navigate to and from the filling station, and avoid obstacles.

5. Have students present their final simulations, explaining the problem, solution, and role of AI. If possible, invite community stakeholders who might be impacted by these problems and solutions to watch and provide feedback on the presentations.

Activity 6: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the societal impact of AI on robotics.

- What do you think would be the impact of having an AI-powered robot completing the task in your simulation, as opposed to having a human (or dog) complete the task?
- What parts of your project (information that needed to be perceived or tasks that needed to be performed) were easy for the AI-powered robot to accomplish? What parts were difficult?
- What ethical dilemmas might arise if an AI-powered robot is used to solve the problem you identified or complete the task you simulated?

Extension

Following are three ways to expand students' exploration of the use of AI in robotics:

- If this project piqued students' interest in the capabilities of AI-powered robots, have them research what companies and organizations are currently doing with the technology. An article like "**How 19 Companies are Using Artificial Intelligence to Make Smarter Robots**" would be a good starting point. To continue building on what they have already learned, students should ask research questions like: What is the purpose of the project or technology? What is the AI doing? What types of sensors are involved in the AI's perception? What type of reasoning is the AI performing? What are the ethical implications and societal impacts of the AI project or technology?
- Students can take their ability to identify and solve problems with AI-powered robots to the next level by competing in the **World Artificial Intelligence Competition for Youth** .
- You can also extend students' thinking about the ethics and societal impact of using AI-powered robots through the "Laws of AI" project found in *Hands-on AI Projects for the Classroom: A Guide for Secondary Teachers*.

> We designed this project to make sure it would work cooperatively with teachers' existing AI robotics hardware platforms of choice and to allow students to explore real-world AI robotics solutions.
>
> — Joe Mazzone, Computer & Software Engineering Teacher, William M. Davies, Jr. Career and Technical High School

PROJECT 4

Machine Learning as a Service

As artificial intelligence technologies become more integrated into many apps and websites used in daily life, the demand for software developers who understand and can use machine learning tools is increasing.

Project Overview

In this project, students explore industry tools and applications of AI through the lens of Machine Learning as a Service (MLaaS). Students gain hands-on experience by experimenting with demos of several image recognition services. Then they develop their own image recognition machine learning model using Teachable Machine.

SUBJECT

Computer science

ESTIMATED DURATION

4–5 hours

TARGET GRADES

8–12

OBJECTIVES

At the end of the project, students will be able to:

- Explain the benefits of MLaaS.
- Describe how an MLaaS image recognition tool works and how it might be used to solve a real-world problem.
- Develop a practical machine learning model using an MLaaS tool.

VOCABULARY

deep learning
face detection
facial analysis
image recognition
machine learning
Machine Learning as a Service (MLaaS)
model (machine learning)
neural network
object detection
transfer learning

STANDARDS

ISTE Standards for Students

1. Empowered Learner

- **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

4. Innovative Designer

- **c.** Students develop, test and refine prototypes as part of a cyclical design process.

5. Computational Thinker

- **b.** Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

ISTE Computational Thinking Competencies

1. Computational Thinking

- **e.** Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. Equity Leader

- **e.** Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

AI4K12 Five Big Ideas in AI

3. Learning

Computers can learn from data.

5. Societal Impact

AI can impact society in both positive and negative ways.

CSTA K-12 Computer Science Standards

2-DA-09: Refine computational models based on the data they have generated.

2-IC-20: Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

3A-AP-13: Create prototypes that use algorithms to solve computational problems by leveraging prior student knowledge and personal interests.

3A-IC-24: Evaluate the ways computing impacts personal, ethical, social, economic, and cultural practices.

3B-AP-09: Implement an artificial intelligence algorithm to play a game against a human opponent or solve a problem.

3B-IC-26: Evaluate the impact of equity, access, and influence on the distribution of computing resources in a global society.

Preparation

MATERIALS

- Computer(s) or tablet(s) (one per student or group) with internet connection for accessing tools and resources online.
- Teacher computer and projector.
- One KWL chart per student. Students may create their own, or you can distribute premade charts.
- Digital stock photographs. Openly licensed stock images can be found through various online sources, such as Search Creative Commons and Pics4Learning.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "A Comprehensive Beginner's Guide to Machine Learning as a Service"
- Article: "What is Deep Learning?"
- Resource: "Face Detection Concepts Overview"

ADVANCED PREPARATION

- Familiarize yourself with each of the MLaaS platforms used in the project.
- If students will be using Amazon Rekognition or Runway ML during their exploration of image recognition tools, you should establish AWS Educate and/or RunwayML accounts and become familiar with their platforms ahead of time. RunwayML would also need to be downloaded onto student computers.
- Prepare a set of stock photographs in at least two categories to use for training data and testing data while demonstrating Teachable Machine in Activity 4.

Instructions

GETTING STARTED

Activity 1: KWL Chart

In this activity, students will use a KWL chart to reflect on what they know and want to know about the **machine learning** topics in this project. They will return to this chart later in the project to add what they have learned.

1. Display a KWL chart for the class. Post the phrase "machine learning" at the top. Explain how a KWL chart is used.
2. Pass out a KWL chart to each student, or have students draw their own.

3. Direct students to work individually to fill out the K column—what students know—by listing facts, terms, or ideas that they know about machine learning. Then have students share some examples of what they wrote, and add them to the displayed class chart.
4. Next, have students fill out their individual W column—what students want to know about machine learning. Then have students share some examples of what they wrote and add them to the displayed class chart.
5. Let students know that they will be learning about machine learning in this project and will return to these charts throughout the project to see what they have learned.

TAKE A CLOSER LOOK

Activity 2: What Is Machine Learning as a Service (MLaaS)?

In this activity, students learn about the purpose and applications of **Machine Learning as a Service (MLaaS)**.

1. Tell students that people, organizations, and corporations all over the world are solving problems in new and innovative ways due to the availability of AI tools. If students are unfamiliar with AI and machine learning, provide students with a high-level introduction to those concepts using resources from Appendix A: Unpacking Artificial Intelligence.
2. Project from 00:49–03:09 of the video "**Intro to Machine Learning (ML Zero to Hero–Part 1)**." Following the video, emphasize that machine learning can solve problems that may be too complex to code by hand, or machine learning can lessen the amount of time it takes to write a program with complex rules. This is because, instead of programming all of the possibilities and solutions for a situation, using machine learning, you can show an AI lots of examples and let it identify the rules or patterns on its own. The AI uses the rules or patterns to create a machine learning **model** that it then uses to make predictions about novel data.
3. Share the story of Makoto Koike, a Japanese systems designer and farmer who developed an AI-powered solution to sort specialty cucumbers for his family farm. Resources: "**How a Japanese Cucumber Farmer Is Using Deep Learning and TensorFlow**," "**TensorFlow powered cucumber sorter by Makoto Koike**."
4. Explain to students that in the early days of machine learning, the development of AI tools was restricted to professional computer scientists, but now there are machine learning services available that allow people from diverse backgrounds to develop AI solutions. Machine learning as a service (MLaaS) is a term that describes a variety of cloud-based machine learning platforms, such as image analysis, recommender systems, chatbots, or translation. These platforms can be integrated into apps, websites, and other applications. MLaaS allows users to quickly get started with machine learning solutions through code-free, user-friendly interfaces and pre-trained models. Major MLaaS platforms include Amazon Machine Learning, Azure Machine Learning, Google Cloud Machine Learning, and IBM Watson Machine Learning.

Activity 3: Experimenting with MLaaS Tools

In this activity, students will learn about machine learning through hands-on experience with two or more industry tools.

1. Have students experiment with two or more of the following MLaaS solutions, providing whole demonstrations as needed. Each of these solutions provide **image recognition** services such as **face detection** (AI that identifies whether there is a face in an image), **object detection** (AI that detects what type of objects are in an image), and **facial analysis** (AI that detects facial details like gender, age, or emotions). Tell students that these are examples of machine learning models that are available for people to integrate into apps or programs that they create. Have students explore the following.

   > **NOTE:** To keep from sharing personally identifiable information, students should only upload stock photos, such as those found at **Search Creative Commons** and **Pics4Learning**.

   - **Google Vision API**. Have students navigate to the Google Vision AI page and scroll down to the Try the API section where they can experiment with a demo of the Vision API. Have students upload an image from their computer or browse online and add at least one stock photograph to see how the machine learning model analyzes various aspects of the image (e.g., face or object detection) and displays the results.
   - **Microsoft Azure's Face API**. Have students navigate to the Face page and scroll down to the demo where they can experiment with the tool. Students can explore how the tool performs with image recognition tasks like face detection or facial analysis using the provided images and/or by using stock photographs via URL or upload.

   Optional: Two additional MLaaS tools can be used by students for image recognition, but these require accounts and/or downloads: Amazon Rekognition and RunwayML. Accessible through the Amazon Web Services console and free through **AWS Educate**, Amazon Rekognition provides user-friendly demos of their image recognition services like face and object detection. Through the downloadable platform **Runway ML**, students can look through pre-trained models to find those that perform face or object detection, such as Face-Landmarks. Test the models by uploading an image for analysis.

2. After students have tried at least two of the AI tools, hold a class discussion to compare and contrast the features and interfaces of the different services. Ask students to identify ways that different MLaaS tools—such as face detection, object detection, and facial analysis—can be used in applications.

3. Have students return to their KWL charts and list things that they have learned in the L column. Then have students share some examples of what they wrote and add them to the displayed class chart. As students share, review key concepts and correct any misconceptions that arise.

Activity 4: Building on an MLaaS Tool

In this activity, students will see how an MLaaS tool can be used to create a machine learning model that performs a custom task.

1. Introduce students to **Google's Teachable Machine** and demonstrate how the tool works by creating an image project. Simple tutorials for gathering examples and training the model can be found on the homepage. Model for students how they can find and use stock photographs for their image data.

   > **NOTE:** We recommend that you use stock photos for this activity. If you choose to use your webcam or personal photographs, please check Teachable Machine's terms of use and privacy policy against your school/district student data privacy policy to ensure the application complies with that policy.

2. Your introduction and demonstration should emphasize these key machine learning concepts:
   - Teachable Machine provides a user-friendly platform for training image recognition models. It is based on an open-source machine learning platform called TensorFlow.
   - TensorFlow uses neural networks for deep learning. **Neural networks** are modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. **Deep learning** algorithms use many layers of nodes to progressively identify both lower- and higher-level features in the input. For example, in image recognition, lower layers might identify edge features, while higher layers might identify features to identify the specific classes, such as faces or objects. Some of these connections are more important than others, so they have more weight in determining the outcome.
   - Just like people, machines learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions.
   - Teachable Machine's Image and Pose Projects build on top of a Tensorflow neural network that has been pre-trained to process images. Teachable Machine uses **transfer learning** to apply the new classes and data the user inputs as the last layer or step of the neural network.
   - Just like the other MLaaS tools that were examined, these models can be trained and customized more effectively, efficiently, and cheaply than developing a neural network from scratch.
   - The step-by-step process for creating a model in Teachable Machine is: create an Image or Pose Project, define classes, upload or input several image samples for each class, train the machine learning model, test the model with new images to see how accurately the model is able to correctly recognize and classify novel images, and iterate to improve the model.

3. Have students return to their KWL charts and list things that they have learned in the L column. Then have students share some examples of what they wrote and add them to the displayed class chart. As students share, review key concepts and correct any misconceptions that arise.

CULMINATING PERFORMANCES

Activity 4: Develop a Solution Using MLaaS

In this culminating performance, students ideate, develop, test, and refine a machine learning model that uses image recognition to address a real-world challenge.

1. Have students work individually or in pairs to consider possible image recognition applications, such as the ones listed below, and select one to develop.
   - Recognizes specific hand symbols, such as those for rock, paper, and scissors.
   - Recognizes objects in images, such as endangered species.
   - Recognizes facial expressions for emotions, such as happiness and sadness.
   - Recognizes different physical poses, such as yoga poses.
2. Then they should use Teachable Machine and an **iterative design process** to create an Image or Pose Project, define classes, upload or input several image samples for each class, train the machine learning model, test the model with new images to see how accurately the model is able to correctly recognize and classify novel images, and iterate to improve the model.

   > **NOTE:** We recommend that students use stock photos for this activity. If you would like to allow students to use their webcam or personal photographs, students should still refrain from using their faces, and you should check Teachable Machine's terms of use and privacy policy against your school/district student data privacy policy to ensure the application complies with that policy.

3. Once students have created their model, each student or pair should demonstrate their working model for the class, explain how the model works, and describe one possible real-world application for the model.

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on the societal impact of MLaaS.

- How do you think the availability of MLaaS will impact software development?
- In what way might these tools democratize the development of AI applications? In what ways might they centralize data with large corporations?
- How do you think that MLaaS will impact the job market in the next ten to twenty years? How might you learn more about pathways to careers in MLaaS?

Extensions

Following are four ways to expand students' exploration of MLaaS.

1. If students have access to an Arduino and a laptop with a webcam, they can take their experimentation with Teachable Machine further through the **Google Tiny Sorter** physical computing experiment. Similar to the cucumber sorter presented in this project, this experiment uses object detection to identify, classify, and physically sort cereal and marshmallows.
2. To provide students with a fuller understanding of deep learning neural networks, you can share the "**But What Is a Neural Network? Deep Learning, Chapter 1**" video by 3Blue1Brown. Additionally, students can advance their understanding of neural networks and deep learning by using **Google's TensorFlow Playground**. Have students try each of the four datasets, progressively advancing from simpler classification data to the most complex classification data, represented by the spiral. Even with the most basic dataset, students should be able to observe the images of what each neuron is outputting and which neurons are given more weight (based on the thickness of the lines) as the model is trained. As the data gets more complex, students will need a combination of more hidden layers, more neurons per layer, more feature property input and/or more training time (epochs) to accurately train the model. Students should adjust settings to see how quickly they can get the model to match the data.
3. Advanced students with experience coding in Python (or a similar text-based language) can work directly with Google's TensorFlow platform and the Keras API to build and train a neural network that performs image recognition based on the MNIST database.
    - Start by sharing these TensorFlow videos, which introduce the basic idea of training a neural network with Python and TensorFlow: "**Intro to Machine Learning (ML Zero to Hero–Part 1)**" and "**Basic Computer Vision with ML (ML Zero to Hero–Part 2)**."
    - Then have students work through the "**Basic classification: Classify images of clothing**" tutorial. This tutorial provides students with an interactive notebook and step-by-step instructions for building, training, and evaluating a neural network that classifies images. An overview of all TensorFlow tutorials can be found at **www.tensorflow.org/tutorials**.
4. Some students may want to spend more time exploring industry AI tools and developing the skills needed for machine learning careers. MLaaS providers often offer tutorials and training programs for potential developers. For example, students who want to further pursue **Google's machine learning tools** can use their free developer courses, guides, and practica. Students ages fourteen and up who are interested in further exploring Amazon's machine learning services can sign up for a student account at **AWS Educate** to access training materials and a wider array of machine learning tools. And IBM offers several courses and resources about using their AI tools on their **Primary and Secondary Education Resources** page.

Glossary

AI agent: an entity that uses sensors and actuators to autonomously act on its environment and achieve goals.

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

artificially intelligent robot (AI robot): a robot that is able to use sensors to collect information and make autonomous decisions about how to complete a task even in a changing environment.

autonomous: having the capacity to act independently or without external control.

behavior tree algorithm: a branching model that controls the flow of decision making through prescribed responses to external cues.

bias: preference for or against an idea or thing.

bot: an AI agent that can interact with computer systems or users (e.g. play video games).

classification model: a mathematical representation of how to categorize data into classes based on common features.

confidence level: the probability that the item has been matched with the correct label.

data: information.

dataset: collection of data.

decision tree: a branching flowchart with nodes, branches, and leaves that symbolically represents a series of tests and classification labels.

deep learning: a machine learning algorithm that uses many layers of nodes to progressively identify both lower- and higher-level features in the input.

ethical: morally right.

face detection: AI that identifies whether there is a face in an image.

facial analysis: AI that detects facial details like gender, age, or emotions.

feature: unique measurable property.

Finite State Machine (FSM) algorithm: a relatively simple AI model that prescribes behaviors for each state in a finite, specific list of all possible states a bot or non-player character can experience in a game.

image recognition: the ability of a computer program to analyze the pixels in an image and identify objects, people, or other subjects.

label: what a machine learning model is trying to predict, such as a class, category, or value.

machine learning (ML): a subset of AI involving the study of algorithms and models that machines use to perform a task without explicit instructions.

Machine Learning as a Service (MLaaS): a variety of cloud-based machine learning platforms, such as image analysis, recommender systems, chatbots, or translation, that can be integrated into apps, websites, and other applications.

model (machine learning): a mathematical representation of a dataset developed by AI.

Monte Carlo Tree Search (MCTS) algorithm: an AI model that uses probabilities of winning playouts from a representation of all possible moves to determine the best next move.

motion planning algorithm: a form of sequential decision making in robotics to support movement and navigation from one point to another.

natural language understanding: an AI technology used to interpret human language.

neural network: a computer system modeled after the human brain that use layers of nodes with weighted, directed connections to learn to perform tasks.

non-player characters (NPC): characters or objects in a game that are not controlled by a human.

object detection: AI that detects what type of objects are in an image.

reinforcement learning: a form of machine learning in which an AI has a clear goal to achieve and learns by receiving rewards or punishments as it makes a sequence of decisions to achieve that goal.

robot: a machine that is able to perform complex tasks automatically.

sampling bias: in machine learning, a preference for or against an idea or thing caused by having a dataset that does not accurately represent the labels.

sensor: a device that allows a machine to perceive the natural world.

sensor fusion: the ability of an AI to combine perception from multiple sensors into one model.

sequential decision making: making a series of decisions.

supervised learning: a form of machine learning in which the trainer provides the AI with labels for each of the items in the training data.

test data: examples used to verify the accuracy of a machine learning model.

training data: examples used to teach a machine learning model.

transfer learning: creating a new machine learning model by tweaking a previously trained neural network.

APPENDIX A

Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, "artificial intelligence is the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and Baymax from "Big Hero 6."

Learn More

Video: "**What is Artificial Intelligence (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**." This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision-making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students**"

Video: "**Algorithmic Bias and Fairness #18**"

Article: "**Ethical Concerns of AI**"

Article: "**Top 9 ethical issues in Artificial Intelligence**"

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

APPENDIX B

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Standards for Students																
Empowered Learner	x	x					x			x	x	x	x		x	x
Digital Citizen					x			x			x			x		
Knowledge Constructor	x		x	x		x	x	x			x		x			
Innovative Designer		x	x				x		x	x					x	x
Computational Thinker			x	x	x		x		x		x		x	x	x	x
Creative Communicator					x	x		x			x			x		
Global Collaborator							x					x	x			

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Computational Thinking Competencies																
Computational Thinking (Learner)				x	x	x	x		x	x	x	x	x		x	x
Equity Leader (Leader)					x	x	x	x							x	x
Collaborating Around Computing (Collaborator)	x			x			x					x	x			
Creativity and Design (Designer)	x	x	x	x				x	x	x	x			x	x	
Integrating Computational Thinking (Facilitator)		x	x				x		x	x				x		

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AI4K12 Five Big Ideas in AI																
Perception	x	x			x					x		x			x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x	
Learning	x			x		x	x				x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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Hands-On AI Projects for the Classroom

A Guide for Electives Teachers

ISTE

GENERAL MOTORS

Hands-On AI Projects for the Classroom

A Guide for Electives Teachers

About ISTE

The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

Related Resources

Teaching AI: Exploring New Frontiers for Learning by Michelle Zimmerman

ISTE online course, ***Artificial Intelligence and Their Practical Use in Schools***

To see all books available from ISTE, please visit **iste.org/books**

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Contents

Foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem-solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, artificial Intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large data sets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in **Appendix A: Unpacking Artificial Intelligence**.

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from jmc.stanford.edu/articles/whatisai/whatisai.pdf

Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority of them are focused on two general areas: automating administrative tasks, such as taking attendance and grading assignments or increasing student performance through AI-supported assessment, personalized learning, and increasing engagement in typically mundane rote learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of this guide is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users and even creators of these powerful tools.

This guide is for educators who teach visual and performing arts, physical education, foreign languages, and other electives or special courses that don't fall neatly into the four core academic areas of English/language arts, social sciences, mathematics, and science. Why devote a guide to these areas of study? Once the stuff of science fiction, AI now permeates nearly every facet of our lives, and while most of us are aware of tools like virtual assistants or navigators, we may not be cognizant of the ways that AI is impacting the arts, sports, journalism, and language acquisition. For example:

- News outlets use AI to generate headlines and articles, to tag and organize the thousands of photos they receive daily, and to create virtual newscasters.
- AI-powered language programs pledge that users will gain fluency in new languages in just twenty minutes of practice per day.
- Film producers use AI to create movie trailers, analyze scripts, and generate virtual actors.
- In sports, AI is used for tasks like the scouting of players, planning and monitoring athlete training programs, and tracking athletes' health and fitness.
- Artists create AI-generated art using tools that apply styles, filters, and other effects to existing images.

These examples point out the importance of all people understanding the degree to which AI is being used to influence our learning, reading, entertainment, physical activity, and more. Awareness at this level does not require specific technical expertise. Educators with little or no prior experience with AI may still help their students become more informed about AI technologies. They can help by identifying instances of AI use, exploring the ethics of machines influencing the decisions we make, and reminding students that AI is a tool created by humans.

Until recently, conventional wisdom has held that the areas of study targeted in this guide are unaffected by AI—that creativity demands human input. For now, this may be true to an extent, but it is entirely likely that in the not-too-distant future, people who want careers in these fields will be required to incorporate AI into their work to some degree. In many instances, this will simply necessitate that the end-user (director, choreographer, coach, journalist, or educator, for example) understand how to use an AI tool to block a play, choreograph a dance, profile an athlete's strengths and weaknesses using data collected with wearable technology, access a curated collection of news images,

or teach students how to use a tool that will help them learn a new language most efficiently. In other cases, an artist may need to create their own machine learning model that will classify images they wish to use. Each of these examples emphasize that, while the people who design these tools will likely be coming from math, science, and computer science disciplines, end-users like artists, performers, coaches, and educators must be participants in the conversation if these tools are to effectively meet their needs.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach

The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their understanding of how AI technologies work, and create various authentic products—from presentations to artwork—to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the standards, concepts, and depth that would be appropriate to elective classrooms. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education,

exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in computer science or AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, the AI and Art project can be completed by students of upper elementary, middle, and high school grade levels; however, students' understanding of the machine learning and neural networks that power the style transfer art applications should deepen as they get older. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI (shown in Figure 1).

The Five Big Ideas in AI serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution, Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities,

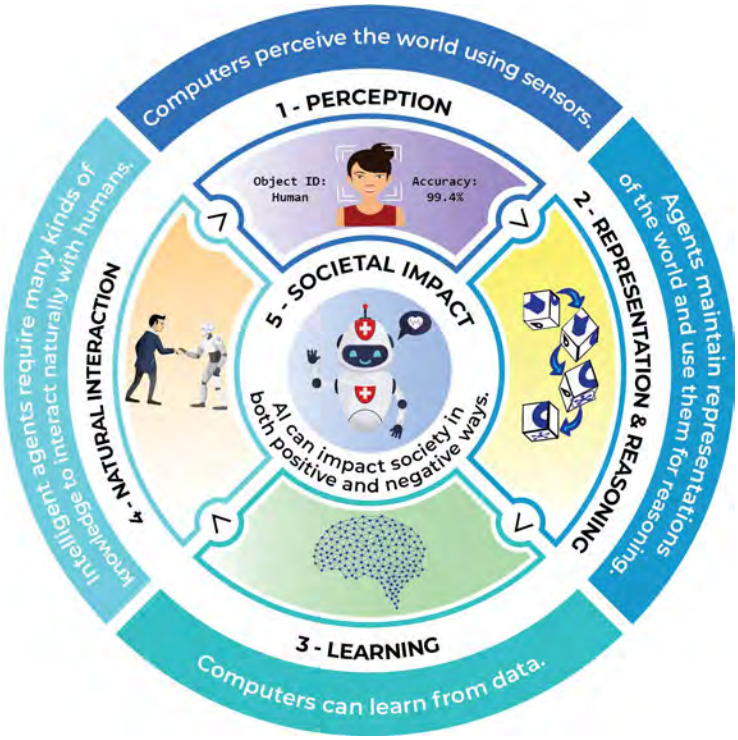

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both online and offline that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendices. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the *Hands-On AI Projects for the Classroom* series
- A discussion entitled "What Is AI?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows.

Project Overview

The project overview offers an explanation of what the project is, how it ties to research-based standards, and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject, target grades, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

Preparation provides the information educators need in order to put the project into action with students. This section includes a list of materials required for project completion; a list of supporting resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools, reviewing online resources, etc.

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.
- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject area content.

- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE. ISTE does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Glossary and Appendices

Glossary

The glossary includes definitions for terms found in the projects that may be unfamiliar or need explanation for students.

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in all four guides in the *Hands-On AI Projects for the Classroom* series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1

Create an AI Expert Guessing Game

Whether in music, language learning, or sports, subject-matter experts have a deep understanding of their specific discipline. For example, they might know nuances of every composition in Mozart's catalog or all the statistics of the latest Olympic record breakers. Based on that knowledge, they are able to make critical distinctions, decisions, or recommendations to others in their field.

Project Overview

In this project, students will think about how experts classify information about a specific subject, then transfer that knowledge to think about how AI can classify large sets of data and use that information to make decisions to solve real-world problems. They will apply this knowledge to create a guessing game based on their coursework. This project would be great for synthesizing knowledge at the end of a course unit or for reviewing content-area knowledge at the end of the year.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

2–4 hours

TARGET GRADES

4–12

OBJECTIVES

At the end of this project, students will be able to:

- Use a decision tree to classify subject matter data.
- Understand how AI uses classification algorithms to make decisions and solve real-world problems.
- Create a guessing game that simulates an AI classification algorithm.

VOCABULARY

artificial intelligence
branch
classification algorithm
classifier
data
data science
decision tree
features
leaf node
node
symbolic representation
test data
training data

STANDARDS

ISTE Standards for Students

4. Innovative Designer

d. Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

5. Computational Thinker

a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

b. Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

ISTE Computational Thinking Competencies

1. Computational Thinking

b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.

4. Creativity & Design

a. Design CT activities where data can be obtained, analyzed and represented to support problem-solving and learning in other content areas.

5. Integrating Computational Thinking

c. Use a variety of instructional approaches to help students frame problems in ways that can be represented as computational steps or algorithms to be performed by a computer.

AI4K12 Five Big Ideas in AI

2. Representation and Reasoning

Agents maintain representations of the world and use them for reasoning.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Content Area Standard(s)

This project has been designed for implementation in a variety of elective classrooms, from art and music to physical education and journalism. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other advances in that field.

Preparation

MATERIALS

- Writing/drawing materials: Paper, chart paper, magnet boards, and/or sticky notes and drawing supplies.
- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Activity: **Slice of Machine Learning**
- Activity: **Akinator**

SUPPORTING RESOURCES FOR EDUCATORS

Article: "**Understanding Decision Trees**"

Instructions

GETTING STARTED

Activity 1: Classification Activity

In this activity, students will activate prior knowledge about classification strategies by working in small groups to organize a set of data.

1. Display or distribute a list of 20–30 objects or terms from your subject area. For example, in a music class, you might include the names of instruments, types of notes or rhythms, and/or musical genres. Alternatively, a physical education class might have a list of sports, players, and/or equipment.
2. In small groups, have students classify the items on the list into subgroups (and even sub-subgroups). Tell them they can sort the items and represent the data any way they would like. For example, students might organize football players by their team, by their position, or by characteristics of their performance; any of these strategies would be appropriate. Once all students groups have sorted the items, have each group explain to the class how they organized the data, what each category is, and what features the items in a given category have in common.

   > **NOTE:** Sticky notes, chart paper, and/or a magnet board for each group might help them better visualize their groupings.

3. Ask students:
    - How did your classification method compare to that of the other groups? Do you think some ways of organizing the items are better than others? Why?
    - How would experts in our subject matter organize these same items? Why? What evidence do we have of that?
    - AI can be used to classify items in large sets of data based on criteria. What might you do differently to teach a computer to accurately classify the items on the list?
4. Conclude the discussion by letting students know that, in this project, they are going to learn how AI analyzes and classifies information. Then, they will think about ways that AI could be applied to solve problems relevant to their own coursework. Finally, they will create a guessing game that will simulate an AI classification process.

TAKING A CLOSER LOOK

Activity 2: AI Classifiers

In this activity, students consider various types of data representation, then dig deeper to see how AI can use decision trees to classify data.

1. Explain to students that **data**—or information—can be represented in many ways. People can organize data into graphs, charts, patterns, logic models, Venn diagrams, thinking maps, or infographics. Consider showing examples related to your content area.
2. Introduce students to AI and classification algorithms. Key points should include:
    - A description of what **artificial intelligence** is, and that people across all fields are using AI to power decision-making about data sets. This process is part of a bigger field of data analysis called **data science**. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
    - **Classification algorithms** are one way that AI categorizes even large sets of data. Based on the result, computers can recommend or make decisions about what actions to take. Many times, AI is able to find patterns and trends that humans are unable to see, especially when processing very large data sets.
    - **Decision trees** are a type of **symbolic representation**—a representation humans can understand—that AI can use to represent and classify data. Decision trees are branching flowcharts in which each **node** represents a question or test. The answer to each node's question determines which **branch** of the flowchart is followed. The branches might lead to more question nodes and eventually end with a **leaf node** that defines that branch's class label.

3. Have students work through the **Slice of Machine Learning** activity, which shows them how AI can analyze training data and make decisions based on criteria in a decision tree. Students can experiment with the amount of training data, test data, and criteria to make the AI's decisions more accurate. Once they have completed the activity, review the concepts it revealed:
   - The AI tool is called a **classifier**.
   - To train the classifier, you must provide it with **training data**, which are examples from each category it is classifying. In this case, there are two categories: pizzas and not pizzas.
   - The classifier then analyzes the data to recognize the different **features**—or unique measurable properties—between the categories, such as shape or cooking method. It uses this data to create a classification model—in this case, a decision tree. With the decision tree in place, a classification algorithm can determine which category new items belong in.
   - Then the classifier uses **test data** to see if it is able to accurately classify the data based on the classification model.
4. The features used in nodes and the order of the questions in the nodes and branches affect the accuracy of the AI's ability to decide if an item is a pizza.

Activity 3: Solving Classification Problems with AI

In this activity, students consider real-world problems that AI might be able to solve with classification algorithms.

1. Explain to students that classification algorithms, like decision trees, are used by AI to solve many real-world problems. Examples include:
   - Helping spam filters distinguish between what is and isn't spam.
   - Powering speech recognition technologies for virtual assistants and translators to distinguish between words or users.
   - Distinguishing features for facial recognition to open your phone or for visual recognition of a person in the road for a self-driving car.
   - Diagnosing medical conditions by distinguishing between symptoms and combinations of symptoms.
2. Have students brainstorm in small groups to come up with classification problems related to your subject area that might be helped by AI. Students should both determine what type of data would need to be used as well as explain the problem classifying it would solve. Then, have students share their group's ideas with the whole class. Discuss which of those ideas might have the biggest positive or negative impact on that field. Student responses might include:
   - Physical education: Analyzing videos of golf swings to determine if they are effective or ineffective.
   - Music: Classifying new music based on its characteristics, so that an app can make recommendations to users.

- Visual arts: Classifying and tagging a large database of artwork based on the materials used to create each piece, so that they are easier to search.
- Foreign languages: Analyzing recordings of languages in remote communities to determine if the language spoken is common to the region or a unique dialect.
- Home economics: Classifying recipes by featured ingredients, calories, difficulty, or taste.

CULMINATING PERFORMANCES

Activity 4: Create an AI Expert Guessing Game

In this activity, students will develop their own decision trees to classify information from their coursework. Students will use their decision trees to simulate a Twenty Questions game with an AI agent.

1. Introduce students to the web and app guessing game **Akinator**, which uses AI to analyze answers to yes or no questions to identify a real or fictional character. As time allows, have students try the game as a whole class or as individuals to test its ability to narrow down people in different categories based on the user's answers.
2. Have students work as individuals or in small groups to create a decision tree to classify information in your content area into categories. Students can do this on paper or using a concept-mapping tool like **Coggle** or **LucidChart**. Let students know that they will later use this decision tree to simulate their own AI guessing game with their classmates. The decision tree should:
   - Be about a specific topic related to the content area you are studying, such as music genres, types of balls, or French verb conjugations.
   - Have between four and ten categories, represented by the leaf nodes.
   - Have a connected series of nodes that each ask a yes or no question. The top node(s) should have the most broad question(s) so that each side of the tree is balanced.

     > **NOTE:** More advanced students might want to create nodes with questions that have more than two possible answers, such as red, blue, or green.

   - Have branches off each node that connect to either the next question or the final category on that branch.
3. *Optional:* Have students prepare for the game portion of this activity by creating a game title and visually appealing version of their decision tree.
4. For the simulated AI expert guessing game, have students work in small groups. Each round, the group will pick one decision tree to work with. One student will secretly choose an item that would fall into only one category (leaf) on that tree. Then, another person will act as the AI, using only the questions and branches on the decision tree to try to guess the other player's item. Then, the group will move to the next round and test another tree.

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on their learning, and consider the societal impact of using AI technologies for classification.

- How accurate were your decision trees? Were there questions that you included, but probably shouldn't have? Were there questions that you didn't include, but should have? (Possible takeaway: The accuracy of the data and the tree affects the accuracy of the AI's decisions.)
- Did you always agree with the yes or no answers that your classmates gave? Or would you have described, distinguished, or classified some of the categories differently? (Possible takeaway: The classification can be biased based on human input, lack of balance or representation in the data set, or other reasons.)
- What if you needed to add another category to your tree? How would that affect the rest of the tree? (Possible takeaway: As fields advance, AI technologies will need to continually learn to continue making accurate decisions.)
- Based on your experiences in this project, what is one real-world problem you would want AI to use classification to help solve?

Extensions

Here are two ways to expand students' exploration of classification algorithms:

1. For hands-on experience with an AI classification tool, have students experiment with **Google Lens**, which analyzes and classifies images from a mobile device camera. Students can see whether this specific neural network is able to correctly identify objects related to your content area and discuss more advanced AI classification concepts like vector representations, confidence levels, or reasons why the result might be wrong.
2. If students enjoy working with a classifier app, they can create their own with the Image Classification project from **App Inventor** and various image classification or decision tree learning projects, like Car or Cup, from **Machine Learning for Kids**.

Since some of these extension activities collect and analyze students' images, please check the account requirements for each activity against your school/district student data privacy policy to insure the activity complies with that policy. In addition, some activities' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

PROJECT 2
Design an AI Agent

People may envision interacting with AI agents in a natural, human-like fashion; however, at this point in time, AI agents are able to use language only in a limited way and cannot converse with humans fluently, consistently recognize facial expressions or emotions, or make inferences about human behavior based on interactions. Students need to understand both the complexity of these types of interactions and some of the challenges faced in developing technology that could enable more nuanced levels of interaction.

> I teach more than one elective—media as well as computer science courses. Although the nature of the courses are different, I feel I could use this project in any of the classes I teach. The resources are excellent and I like that the project is unplugged because it helps me address issues of equity and access among my students.
>
> — **Leah Aiwohi, Computer Science and Media Arts Teacher, Kauai High School**

Project Overview

The purpose of this unplugged project is to give students opportunities to consider what AI agents need to be able to do to effectively interact with humans within the context of fields such as the arts, foreign languages, or physical education. In this project, students explore how AI agents are currently being used in a discipline addressed in this guide. Then they work independently or in groups to identify a task or challenge related to the discipline and design an intelligent agent people could interact with in a natural fashion to complete that task or meet that challenge.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

4–6 hours

TARGET GRADES

6–12

OBJECTIVES

At the end of this project, students will be able to:

- Explain how AI agents are being used in a specific field of study.
- Use a PEAS (Performance, Environment, Actuators, and Sensors) representation to describe the parts of an AI agent of their own creation.

VOCABULARY

AI agent
sensor

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

4. **Innovative Designer**
   - a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.

4. **Creativity & Design**
   - b. Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.

5. **Integrating Computational Thinking**
   - b. Empower students to select personally meaningful computational projects.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.

4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Content Area Standard(s)

This project has been designed for implementation in a variety of elective classrooms, from art and music to physical education and journalism. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other advances in that field.

Preparation

MATERIALS

- Writing/drawing materials (for designing the AI agent): Drawing paper, writing paper, pencils, pens. This work can also be done on a device, if desired, using a word processor or drawing program.
- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Chatbot: **Mitsuku**

ADVANCED PREPARATION

- Review and select resources that provide examples of ways AI is currently applied in your field of study (the arts, sports, journalism, language acquisition, etc.). Sample resources are suggested in the Instructions, but you may prefer to find your own related resources.
- Create appropriate definitions for the following terms: *agent, sensor, actuator, effector, intelligent agent,* and *PEAS Representation*. Possible definitions can be found in the article "**Agents in Artificial Intelligence**."

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students engage in the topic of AI agents through class discussion.

Ask students: Have you ever used a smart device, at home or at school, such as a smartphone, smart TV, Roku, or Nest Hello video doorbell? If you could have a virtual assistant or robot perform any one task for you in this class, what would it be? Give students a chance to brainstorm. As they learn more about AI agents, they will have an opportunity to return to this question later in the project.

TAKE A CLOSER LOOK

Activity 2: AI Agents in Action

In this activity, students will examine how AI agents are currently being used in a specific field of study, such as the arts, sports, journalism, or language acquisition. If students do not have previous experience interacting with an AI agent, you may want to begin this activity by having them interact with the award-winning AI chatbot, **Mitsuku**.

Use the following examples—or others you have curated—to explore with students how AI is currently being used in your field of study. More advanced students may be able to do this research on their own.

1. **AI agents**—in the form of software, virtual assistants, and robots—are currently being used in all fields to make tasks easier or more efficient. Sometimes they are also being used to analyze the work of experts and high performers, identifying defining characteristics and applying them in new ways. Here are some examples:

   - AI is being used to create art in several areas, including visual arts, music, and poetry—and even to write scripts for movies. This art is created through the use of neural networks, which MIT News defines as "a means of doing machine learning, in which a computer learns to perform some task by analyzing training examples." Can AI create images, music, scripts, poetry, and the like? Yes. Are these creations truly art? Maybe, but maybe not. Is AI art better than what human beings craft? That's definitely a matter of opinion at this time.

     Sample resources: "**The Rise of AI Art—and What It Means for Human Creativity**," "**Explained: Neural networks**," "**Neural Network in 5 Minutes**," "**Could a computer ever create better art than a human?**"

   - In early 2019, *Forbes* listed four ways AI is impacting the world of sports. Their list included scouting and player recruitment, player training and assessment, tracking player health and fitness, and—for college and professional teams—enhancing broadcasting and advertising opportunities. Students will likely be familiar with wearable technologies like FitBit or other smart sports watches. And companies are exploring the use of virtual coaches in youth sports like soccer.

     Sample resources: "**Here's How AI Will Change The World Of Sports!**," "**Real-Time Personalized Virtual Training Fills Hole in Youth Sports Coaching Pipeline**"

   - AI is making headway in journalism as well. For example, in 2015, the *New York Times* launched a project called Editor, a text editing interface designed to use machine learning to enable tagging of articles during the writing process. Reuters uses an AI-based data visualization tool that enables news publishers to present readers with charts, graphs, and tables that represent complex information in understandable formats. And the *Washington Post*, Yahoo! Sports, and the Associated Press are all using AI to create news stories in one or more of the areas of entertainment, sports, and finance. Fact-checking is another area being supported through the use of AI.

     Sample resources: "**Automated Journalism—AI Applications at New York Times, Reuters, and Other Media Giants**," "**Artificial intelligence-enhanced journalism offers a glimpse of the future of the knowledge economy**"

   - Teaching or learning a foreign language? AI-supported translation apps facilitate on-the-spot communication in multiple languages, and language-learning apps can be used to build vocabulary and practice speaking a new language. While some fear that these apps may make foreign language teachers obsolete, others say that the apps offer a great introduction to a new language, but human instructors are still a critical part of learning the mechanics of grammar and pronunciation, not to mention the nuances of language.

     Sample resources: "**Artificial Intelligence: The Angel of Death for Foreign Language Teachers**," "**Artificial Intelligence in Language Learning**"

2. Discussion: Have students explore several of the examples of AI technologies shared in the resources provided below that relate to your content area(s). Ask students: What do you think? Are there tasks where AI outperforms humans and tasks where it does not? Explain what you think and why.
   - **The Top 25 AI Artists of 2019**: Learn about some of the people who are creating AI art and what they hope to accomplish.
   - **AI Art Gallery**: Collection of AI-generated art.
   - "**Musical Artificial Intelligence—6 Applications of AI for Audio**": Learn about some ways AI is used to create and share music.
   - **Celebrating Johann Sebastian Bach**: Try your hand at using AI to create music in the style of J. S. Bach.
   - "**You'll Never Dance Alone with This Artificial Intelligence Project**": Building co-creative AI dances. Two videos are included.
   - "**Is Google the World's Next Great Choreographer?**": Using AI to choreograph dances. One video is included.
   - **Creative Tools to Generate AI Art**: Comprehensive list of AI tools used to create everything from images to text to music.
   - "**Google's prototype AI translator translates your tone as well as your words**": Learn about Google's new AI translation system called Translatotron, which translates from one language to another while preserving the voice and tonal nuances of the speaker.
   - "**Why is AI a good thing for language teachers and learners?**": A discussion of some ways AI might enhance the teaching and learning of foreign languages.
   - "**The best translation apps: which is the right one for you?**": Translation apps for iOS and Android.
   - "**Technology helping youth baseball players train smarter**": An example of how AI is being used to help student athletes train more effectively.
   - "**AI Coaches Are Here to Unleash Your Inner LeBron**": AI and training for basketball players.
   - "**How AI Is Saving Orthopedic and Sports Medicine Practices An Hour Each Day**": How is AI being used in sports medicine?
   - "**Will AI Save Journalism—or Kill It?**": Article includes a link to a podcast about robot journalism and a video depicting China's first female AI news anchor.
   - **Write with Transformer**: Use this free tool to experiment with how a modern neural network completes text.
   - **AI + Writing**: Check out these Google Experiments that use AI to write.

CULMINATING PERFORMANCES

Activity 3: Design an AI Agent

In this unplugged activity, students use AI vocabulary and concepts to design an AI agent that has the capabilities it would need to perform a task in a given content area. Depending on students' ages and skill levels, you may want to have them complete this activity as a whole class project, in small groups, or individually.

1. Begin by sharing and discussing the definitions for the following terms: *agent, sensor, actuator, effector, intelligent agent,* and *PEAS Representation.* There are many online resources available for defining these terms. JavaTpoint offers all six on one page in simple terms: "**Agents in Artificial Intelligence**."
2. Ask students to brainstorm a list of tasks or challenges they encounter in your class. Create a class list of these ideas. Select one from the list to use as a model. For example, perhaps you teach an art or shop class where, as a result of the kinds of projects being done, the floors need to be swept at the end of each activity. This cuts significantly into class work time. Students might suggest creating an intelligent agent that could solve that problem. A logical solution might be a robot that uses AI to clean the classroom floor at the end of the period so that students are able to use all class time for creative work. What would this robotic device consist of?
3. Using the PEAS Representation model, walk the class through your example by filling out a PEAS Representation, drawing a picture or giving an example of it in action, and writing a brief description of what this intelligent agent looks like and how it will solve the problem identified. See the example in the following table:

SweepBot	
The purpose of this intelligent agent is to preserve instructional time for class work by completing cleaning chores that have previously been done by students.	
Performance measure	Clean classroom floors, increased project work time for students, safe classroom environment
Environment	Art/shop classroom, large work tables, stools, equipment, dry and wet trash on the floor, other obstacles
Actuators	Pneumatic actuators (cylinders and motors), wheels, brushes, vacuum
Sensors	Cliff sensors, bump sensors, wall sensors, optical encoders, and dirt detection sensor

4. Once students have completed the example PEAS representation as a class, have students work independently or in small groups to identify a task or challenge related to their course and design an intelligent agent people could interact with in a natural fashion to complete that task or meet that challenge. Students should develop a presentation for the class that includes:
   - A PEAS Representation of their AI agent

- A drawing or a written example of the AI agent in action
- A written description of what the intelligent agent is and how it will solve the problem identified

Activity 4: Reflect

In this activity, students should discuss the following question to reflect on their learning and consider the societal impact of using AI agents.

- Lead the following discussion: Consider how the intelligent agent you designed for this project could impact your life or the lives of those around you. What are the pros/cons of using an intelligent agent to perform that task instead of having a person perform them?

Extensions

Here are two ways to expand students' exploration of AI agents, natural interaction, and user interfaces:

1. There are natural user interface designers who strive to develop intelligent agents that capitalize on human's abilities to interact with digital objects using capabilities like vision, speech, gestures, or handwriting. The rationale for this focus is to make the use of technology as transparent as possible.

   Sample resources: "**Natural Digital Conversations with Intuitive and Smart Chatbots**," "**Guidelines for Human-AI Interaction**"

   Class discussion: Brainstorm a list of technologies students regularly use. Then discuss ways they interact with these technologies. For example, they may include keyboards, mice, game controllers, touch screens, voice, handwriting, etc. How might environment impact the ability to interact with a device? What about physical disabilities or language challenges? Ask students which devices are easiest for them to use and why. Ask them which kinds of interaction they think most people prefer.

2. As we work to achieve transparent interactions with technology, it's important that we ensure that children and adults are able to recognize that there are differences between humans and intelligent agents—that humans are able to control intelligent agents. One strategy for achieving this separation is to refrain from anthropomorphizing these machines.

   Sample resources: "**PopBots: An early childhood AI curriculum**," "**The Danger of Anthropomorphizing AI**"

   Class discussion: Brainstorm a list of intelligent agents students currently interact with. For example, they may include Siri, Google Voice, Alexa, and similar agents. Ask students what pronouns they use to refer to these agents and why. Have a discussion about why interface designers might want to make intelligent agents seem to be almost human. Include a discussion about the fact that these devices are not "magical."

PROJECT 3
AI and Art

Human artists are able to apply various artistic approaches to create artwork with a unique style of their own. When we think about the art of Vincent Van Gogh, Claude Monet, or Roy Lichtenstein, a distinct set of stylistic characteristics come to mind.

Project Overview

In this project, students will examine the unique characteristics of various artistic styles and then see how an artificial neural network can be used to learn and apply stylistic elements in artwork.

> I love the simplistic lesson plan with its clear objectives and steps for instruction. The advanced planning links are very helpful!
>
> — **Vickie Waite, Computer Science and Video Production Media Arts Teacher, Maclay Middle School**

SUBJECT

Visual arts

ESTIMATED DURATION

3–4 hours

TARGET GRADES

4–12

OBJECTIVES

At the end of this project, students will be able to:

- Explain the basics of how machine learning and neural networks work.
- Discern between distinguishing characteristics of various artists and artwork.
- Create original artwork that remixes multiple images and styles using a digital tool powered by an AI neural network.

VOCABULARY

artificial neural networks
extract
feature
machine learning
model
nodes
style transfer tools

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. **Digital Citizen**
   - **c.** Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.

3. **Knowledge Constructor**
   - **a.** Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.

5. **Computational Thinker**
   - **b.** Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

6. **Creative Communicator**
   - **b.** Students create original works or responsibly repurpose or remix digital resources into new creations.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - **b.** Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.

4. **Creativity & Design**
   - **d.** Create CS and CT learning environments that value and encourage varied viewpoints, student agency, creativity, engagement, joy, and fun.

AI4K12 Five Big Ideas in AI

3. **Learning**
   Computers can learn from data.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

National Core Arts Standards

Anchor Standard 2

Organize and develop artistic ideas and work.

Anchor Standard 7

Perceive and analyze artistic work.

Preparation

MATERIALS

- Computers with internet connection for accessing tools and resources online (one per student or group). Alternatively, most recommended project tools except **Teachable Machine** will also run on mobile devices.
- Teacher computer and projector.
- Tools: **Google Tags experiment**, **Google's Curator Table**, **Teachable Machine**

ADVANCED PREPARATION

- Select an AI style transfer tool (defined and used in Activity 5: Neural Art), such as **Deep Dream Generator**, **DeepArt**, **Deep Style**, or the **Prisma** app for iOS or Android.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will activate prior knowledge about art as they consider how they describe and characterize artists' styles.

1. Ask students to imagine that a friend is going to a large art museum. While you don't know exactly what pieces will be included, you want to make sure your friend looks for art by your favorite artist. How might you describe the artist's style so that your friend recognizes their artwork without reading the name of every piece's artist? For example, does your favorite artist use primary colors or pastels? Do they work with paint or pencil or clay? Do they typically portray nature, people, animals, objects, or shapes?

   > **NOTE:** If you are working with elementary students who do not have much experience with famous artists or artwork, this same activity can be done with children's book illustrators, such as Eric Carle, Shel Silverstein, or Anna Dewdney.

2. Now, ask students to imagine that they wanted to teach a computer to recognize artwork by the same artist. Do they think they could use the same descriptions, or would they need to use a different method?
3. Conclude the discussion by letting students know that, in this project, they are going to learn how AI technologies are being used to identify, organize, tag, and even create art. By the end of the project, they will be able to meet each of the three project objectives.

TAKING A CLOSER LOOK

Activity 2: Explore with Students

In this activity, students will look at how AI is used to visually analyze, organize, and tag art.

1. Project the "**Every piece of art you've ever wanted to see—up close and searchable**" TED Talk video, prompting students to think about how AI is being used to analyze and organize the combined art collections of over one thousand museums and archives in **Google Arts & Culture Project**.
2. Direct students to explore how AI visually perceived, analyzed, and tagged the collection's artwork through the **Tags experiment**.

Activity 3: Identifying Artists' Styles

In this activity, students will analyze and characterize artists' styles.

1. Project the **Google Tags experiment** and search for an iconic art tag. As a whole class, challenge students to analyze the tagged artwork. For example, if you examined the tag "water lily," ask students:
   - Given the characteristics of Claude Monet's art (such as nature images; paintings; short brush strokes; natural lighting; or strong, unmixed colors), can you identify which of these pieces are his just by looking at them?
   - Knowing which of the water lily images are Monet's, would you add any other characteristics to the description to better identify which ones are his?
   - Based on those same characteristics, would you be able to tell that the red and pink "Peony Garden" tagged with "water lily" is a Monet by the style of painting (even though the colors and content are different)? How might you need to change the list of characteristics to include Monet's works that do not include water lilies?
2. Have students—as individuals or in small groups—research two or more artists that you are studying in your course and **extract** the indentifying **features** of their styles into a list. For example, if students are studying Dutch painters, they might characterize Vincent Van Gogh's style as having thick brush strokes (impasto), bold colors, portraits, and landscapes, while characterizing Piet Mondrian's style as having straight lines, right angles, primary colors, black, and white. Students can find collections of artists' works by using a resource like **Google's Curator Table** and can then organize these criteria using a digital or paper-based graphic organizer, such as a classification tree, Venn diagram, or brace thinking map. Enhance this activity by reinforcing specific stylistic characteristics and vocabulary from your curriculum.

3. *Optional:* Conclude with a partner game in which students trade graphic organizers, show each other a piece of art by one of the artists they researched, and have the other guess the artist based on listed characteristics.

Activity 4: Training an AI Art Recognition Model

In this activity, students will transfer their own experience of style extraction to see how AI can be taught to extract similar types of stylistic characteristics. Then, students will train a machine learning model to recognize artists' work.

1. Provide a basic description of AI and machine learning to students. Supporting resources can be found in **Appendix A: Unpacking Artificial Intelligence**.
2. Explain to students that we can train AI to identify the style of an artist much like we analyzed an artist's works in the last activity. Key points should include:
   - **Machine learning**, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use artificial neural networks to build a model that it can use to make decisions or predictions.
   - **Artificial neural networks** (ANN) are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of **nodes** with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome.
   - Just like people, machines learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a **model** from which to make future predictions or decisions.
   - For example, to teach a machine to identify the artist of a work of art, we could provide a neural network with many examples of art by the artist and let it visually analyze those works to find a pattern of common characteristics among them. Then, when the model is tested with a new work of art, it would look for those characteristics to determine if it is by that artist. It could also use that model to apply those characteristics to another image to make it look like it is created in the style of that artist.
3. Have students train an art recognition model with Google's **Teachable Machine**. Students can create an image project, define classes for multiple artists or styles of art, upload several image samples for each class, train the machine learning model, and then test the model with new art images to see how accurately the model is able to recognize and classify the artwork by artist or style.

> **NOTE:** For elementary students, this step can be skipped or the model training could be done as a class. Older students could work as individuals or in small groups to train a model to recognize work by the artists they previously researched.

CULMINATING PERFORMANCES

Activity 5: Neural Art

In this activity, students will use an AI-powered style transfer tool to apply the style of one artwork to the content of another.

1. Introduce students to an AI-powered **style transfer tool**, such as **Deep Dream Generator**, **DeepArt**, **Deep Style**, or the **Prisma** app for iOS or Android. These AI-powered style transfer tools use pre-trained neural networks that have been taught to do three things: identify essential content elements in one image, identify essential stylistic elements in a second image, and combine the two models to create a third merged image. When you provide the neural network with a content and style image, it analyzes them similarly to how the students did, identifies the most essential characteristics, and uses that data as the last step or layer in the neural network. It then synthesizes the most essential content and style characteristics to create a third merged image (see Figure 2).

FIGURE 2. Merged image created from content image and style image using DeepArt.

2. Provide students with a demonstration of the neural art tool they will be using.
   - Show them a sample content image and a style image to be used.
   - Prompt students to make a prediction of how the merged output image will appear.
   - Run the program with the content and style images. Show students the merged image and have them compare and contrast the AI output to their predictions.

3. Have students use the style transfer tool to create their own neural art project that combines a content and style image to create a final merged "neural art" image. Students should use original art or photographs for their content images or may remix others' works in accordance with their copyright or license. Finished projects should include:
   - The content, style, and merged images.
   - A written description of how the AI-powered tool processed the specific images they provided, including what content and style elements the neural network identified and merged.

   > **NOTE:** More advanced students may also want to upload their own style images, such as a work of art by the artist they were previously researching.

4. Finish this activity with a gallery walk where students can view and even provide feedback on each other's artwork.

Activity 6: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the societal impact of using AI technologies to generate art.

- How does art created with AI differ from art created solely by human artists?
- Do you think art made with AI counts as real art?
- If an artist uses AI technologies to create their work, who would you define as the artist—the human, the AI, the programmer that developed the AI, or the person that trained the AI?
- How do you think AI technologies might change the way people make art now and in the future?

Extensions

Here are two ways to expand students' exploration of AI and art:

1. You can facilitate a deeper dive into machine learning, neural networks, and creating both visual art and music with AI technologies with free curricula and resources from these two organizations. Submit the information form on each website to learn more and/or access the free resources.
   - **MozAIrt**. The mission of MozAIrt is to inspire students about AI through humanistic applications that are focused on music and art, with hands-on workshops involving both hardware and software learning.
   - **CreAIte**. CreAIte's mission is to inspire students about AI through artistic applications of technology.
2. You and your students can also explore additional AI-powered art tools and what artists are doing with them at **AIArtists.org**.

PROJECT 4

AI-Powered vs. Human Translators

Thanks to the use of AI and machine learning, translation results are far more accurate than they used to be. Translation apps are still no substitute for learning to speak a foreign language, but they can be used to increase mastery of a foreign language and to enable users to function in situations where they need to communicate with someone who speaks another language.

Project Overview

In this hands-on project, students work independently or in pairs to translate text (words, phrases, paragraphs) into a target language and parse those translations to determine the accuracy of at least two AI-powered translators. Then they engage in a live conversation with a fluent speaker of another language other than English using the translator they have identified as being most reliable. The purpose of this project is to help students develop an understanding of how AI-powered translators function, make determinations and predictions about their accuracy, and use a translator to carry on a conversation with someone fluent in a language other than English. It is also a way to involve students in exploring how AI benefits translation and when it is a better choice not to use AI.

> I'm excited about this project because it can help show my students when it's appropriate to use a translator and when it is not. For instance, a translator is a good communication tool to use when you do not speak a specific language, but it is not a good tool for learning how to speak another language.
>
> — **Julianne Lowenstein, French Teacher, Wissahickon Middle School**

SUBJECT

World languages

ESTIMATED DURATION

3 hours

TARGET GRADES

8–12

OBJECTIVES

At the end of this project, students will be able to:

- Compare and contrast the accuracy of the output of human and AI-powered translators.
- Use an AI-powered translator to hold a real-time conversation with a speaker of another language.

VOCABULARY

AI
machine learning
natural language processing

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use, and troubleshoot current technologies, and are able to transfer their knowledge to explore emerging technologies.
7. **Global Collaborator**
   - **b.** Students use collaborative technologies to work with others, including peers, experts, or community members, to examine issues and problems from multiple viewpoints.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - **b.** Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.
3. **Collaborating Around Computing**
   - **c.** Plan collaboratively with other educators to create learning activities that cross disciplines to strengthen student understanding of CT and CS concepts and transfer application of knowledge in new contexts.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.
2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.

4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

ACTFL: American Council for the Teaching of Foreign Languages Standards

ACTFL 1.2: Students understand and interpret written and spoken language on a variety of topics.

Interpersonal Communication–Standard 3.1: Students reinforce and further their knowledge of other disciplines through the foreign language.

Connections–Standard 4.1: Students demonstrate an understanding of the nature of language through comparisons of the language studied and their own.

Preparation

MATERIALS

- Writing materials: Paper, pens and pencils, dry erase boards, worksheet with vocabulary, sentences, and paragraphs to be translated.
- Computer(s) or mobile device(s) with internet connection for accessing tools and resources online.
- Two or more translator tools, such as **Google Translate**, **Microsoft Translator**, **Deep Learning Translator**, or **Skype Translator**. Another option is to use Siri on iPads or iPhones.
- Teacher computer and projector.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Google's AI Can Now Translate Your Speech While Keeping Your Voice**"
- Article: "**AI Won't Replace Human Translators Yet. Here Are Three Reasons Why**"
- Article: "**For AI, Translation is about More than Language**"
- Article: "**Google's AI Now Translates Your Speech in Your Exact Voice**"
- Tool: **Mondly App for language learning**
- Tool: **Skype Translator**

ADVANCED PREPARATION

- Select apps and websites to be used for translation. Make sure all are accessible on school network and devices.
- Prepare vocabulary words, phrases, sentences, and paragraphs for students to translate into the target language.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students consider the topic of AI-powered translators through class discussion.

- Ask students: Have you ever used an AI-powered translation tool like Google Translate or Microsoft Translator? What are your thoughts about them? Do they replace the need to learn how to speak a foreign language? Give students a chance to brainstorm. As they learn more about AI-supported translators, they will have an opportunity to return to this question later in the project.

TAKE A CLOSER LOOK

Activity 2: Introduction to AI-powered Translation Apps.

In this activity, students will explore AI and machine learning as they consider how these capabilities are currently being used to help people communicate in multiple languages.

1. Begin by defining **AI** and **machine learning**. Have students brainstorm a list of ways these technologies are used in daily life. Supporting resources can be found in **Appendix A: Unpacking Artificial Intelligence**.
2. Explain what **natural language processing** is, how it processes and analyzes large amounts of data—such as language—and translates it/negotiates its meaning. Include a discussion of potential pros and cons of the use of AI and machine learning for natural language processing. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
3. Introduce AI-powered translation apps. AI-powered translation apps facilitate on-the-spot communication in multiple languages not only by translating written and spoken words from one language to another, but also by accurately conveying the meaning of the words being translated. This means that it's easier to avoid mistranslations than in the past, but does not mean that AI translators negate the need to actually learn how to speak a foreign language. While the capabilities of today's AI translators are far greater than even a few years ago, they are still not perfect. However, these translators can be used to help students increase their vocabularies and learn syntax and grammar. They can support real-time conversations, assuming students have enough knowledge of the language to be able to evaluate the efficacy of multiple AI translators to determine which are most reliable. AI-powered translators can also be leveraged to personalize student learning by providing immediate feedback and enabling students to work independently.
4. Support your introduction with these or other resources:
   - "**AI Translators: The Future of Language Learning?**" The text is informative. The video contains one mild expletive.
   - "**Preparing Teachers for the Application of AI-Powered Technologies in Foreign Language Education**". PDF download.

- "**Artificial Intelligence: The Angel of Death for Foreign Language Teachers**"
- "**Artificial Intelligence in Language Learning**"

5. Discuss: Given what students already know about learning to speak a foreign language, what strategies could they use to test the reliability of at least two AI translators? Brainstorm a list of suggestions—for example, parsing sentences that have been translated is a way to judge the quality of that translation.

Activity 3: Test-Drive a Couple of Translation Tools

In this activity, students try out at least two AI translation tools to determine which one they will use during live conversations with people who are fluent in the language students are studying. Depending on students' ages and skill levels, you may want to have them complete this activity as a whole class project, in pairs, or individually. Also, as written, this activity is a five-step process, but you may decide to skip the second step based on your students' familiarity with basic vocabulary words in the target language.

1. Begin by reviewing available tools for translating languages and communicating including dictionaries, human translators, and apps/web tools for translation, as well as headphones and other electronic translation devices that are available. Explain that for this project students will evaluate the accuracy of AI translators readily available for use on mobile devices, such as smartphones or tablets.
2. Provide students with a list of vocabulary words to translate from English to the target language using a dictionary or glossary. Depending on the length of the list, allow 5–10 minutes for students to work in pairs to complete the translation. Ask students to share their answers before using the AI translator. Then, ask them to use an app or web tool to translate the same vocabulary list. Have each partner use a different AI translator so they can compare their results and compare how well each of their offline translations align with the AI-supported results. How much time does using an AI-powered translator require? Are the answers generated by the app or web tool the same as those found in the dictionary or glossary?
3. Next, provide students with a list of sentences to translate from English to the target language using a dictionary or glossary. Depending on the number of sentences, allow 15–20 minutes for students to work in pairs or small groups. Ask students to share their responses before using their AI translators. Then, ask them to use the app or web tool to translate the same sentences. Which is more efficient? Parse the responses, reviewing the syntax of the translated sentences and the differences in word selection. Discuss words which may be confusing for a nonhuman translator, such as homophones and homographs, including bat, hang out, pen, invalid, resume. How do humans know the difference? How might AI know the difference? How does context impact meaning and word choice?
4. Repeat this process one more time, giving students one or two paragraphs to translate first on their own and then using their AI translators.
5. Discuss: How is this experience similar to translating words and sentences and how is it different? As the text to be translated becomes more complex, is there a shift in the quality of the translations? What are the benefits of using translators? What are the drawbacks? Which translator is easiest to use and most accurate?

CULMINATING PERFORMANCES

Activity 4: Real-Time AI-Powered Translation

This culminating performance prompts students to explore the use of an AI translator to facilitate conversations with people who speak the target language fluently. The purpose of this activity is to create an environment where students can experience the use of a translator to support conversations beyond their current level of proficiency in the target language. These conversations can take place in the classroom with community members or online with native speakers identified by the teacher.

1. Students need to plan a 5-minute conversation in which they will learn 3–5 things about the person they speak with.
2. Using the conversation feature of the AI translator they have identified as most accurate, students speak English and the person they interview speaks the target language.
3. At the close of the conversation, the student asks the person to rate the accuracy of the translation. Did the translations make sense? Did they struggle with understanding, or was the conversation easy to follow? Were mistakes made? Would they recommend this AI translator as an effective communication tool?
4. Students write an evaluation of the AI-powered translator used for the conversation. Include information about basic specs and the information provided by their conversation partner along with an overall rating of the translation tool.

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the personal and societal impact of using AI-powered translators.

1. Consider the AI translator you used during the final conversation. Would you be able to use this tool in an environment where you needed to communicate with people who do not speak English? For example, could you use this app when traveling in a foreign country? How might this facilitate travel?
2. How might this tool enable you to collaborate with non-English speakers? For example, could you use this app to help a new non-English-speaking student feel welcome at your school?
3. What barriers might use of this app raise or lower? Why? How might the use of an AI translator impact your life or the lives of those around you? What are the pros and cons of using an AI translator to learn a foreign language and/or communicate with non-English speakers?

Extensions

Another test of the accuracy of an AI-generated translation is to take the text generated in the first translation and have the tool translate that text back into English. How close to the original English is this translation? Why are there differences? What can be learned from this exercise?

> As a language teacher, I realize that there are many opportunities available through online language translators that students may try to use rather than doing their own translation. I often discuss these tools in class to help students to better understand how these tools should or could be used. Being able to recognize the difference in using these tools to assist in learning, for example to translate a word and have options to choose from, versus using a translator to complete an entire translation, is important. It is important that our students understand how the technology works. For anyone implementing the project, I recommend providing commonly mistranslated phrases or words that humans would quickly be able to distinguish to test the accuracy of the tools and make sure to involve students in the discussions.
>
> — **Rachelle Dene Poth, STEAM and Foreign Language Teacher, Riverview Junior Senior High School**

Glossary

AI agent: an entity that uses sensors and actuators to autonomously act on its environment and achieve goals.

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

artificial neural network (ANN): a computer system modeled after the human brain that uses layers of nodes with weighted, directed connections to learn to perform tasks.

branch: the part of a decision tree that represents the possible options of a node's test.

classification algorithm: a method of categorizing data into classes based on common features.

classifier: an AI classification algorithm.

data: information.

data science: a field in which people work to extract knowledge and actionable insights from data.

decision tree: a branching flowchart with nodes, branches, and leaves that symbolically represents a series of tests and classification labels.

extract: identify or separate out.

feature: unique measurable property.

leaf node: the part of a decision tree that defines that branch's class label.

machine learning (ML): a subset of AI involving the study of algorithms and models that machines use to perform a task without explicit instructions.

model (machine learning): a mathematical representation of a dataset developed by AI.

natural language processing (NLP): the AI technology used to understand and interact with human language.

node (decision tree): the part of a decision tree that represents a question or test.

node (neural network): an artificial neuron that receives weighted input, performs a function, and produces output in a neural network.

style transfer tool: an application that uses a pre-trained neural network to identify essential content elements in one image, identify essential stylistic elements in a second image, and combine the two models to create a third merged image.

symbolic representation: a data representation or model that humans can understand.

test data: examples used to verify the accuracy of a machine learning model.

training data: examples used to teach a machine learning model.

APPENDIX A

Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and Baymax from "Big Hero 6."

Learn More

Video: "**What is AI (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**." This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students**"

Video: "**Algorithmic Bias and Fairness #18**"

Article: "**Ethical Concerns of AI**"

Article: "**Top 9 ethical issues in Artificial Intelligence**"

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

APPENDIX B

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Standards for Students																
Empowered Learner	x	x					x			x	x	x	x		x	x
Digital Citizen					x			x			x			x		
Knowledge Constructor	x		x	x		x	x	x			x		x			
Innovative Designer		x	x				x		x	x					x	x
Computational Thinker			x	x	x		x		x		x		x	x	x	x
Creative Communicator					x	x		x			x			x		
Global Collaborator							x					x	x			

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Computational Thinking Competencies																
Computational Thinking (Learner)				x	x	x	x		x	x	x	x	x		x	x
Equity Leader (Leader)					x	x	x	x							x	x
Collaborating Around Computing (Collaborator)	x			x			x					x	x			
Creativity and Design (Designer)	x	x	x	x				x	x	x	x			x	x	
Integrating Computational Thinking (Facilitator)		x	x				x		x	x				x		

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AI4K12 Five Big Ideas in AI																
Perception	x	x			x					x		x			x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x	
Learning	x			x		x	x				x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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Hands-On AI Projects for the Classroom

A Guide for Secondary Teachers

ISTE

GENERAL MOTORS

Hands-On AI Projects for the Classroom

A Guide for Secondary Teachers

About ISTE

The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

Related Resources

Teaching AI: Exploring New Frontiers for Learning by Michelle Zimmerman

ISTE online course, ***Artificial Intelligence and Their Practical Use in Schools***

To see all books available from ISTE, please visit **iste.org/books**

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ISTE | GENERAL MOTORS

Contents

Foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem-solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large data sets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in **Appendix A: Unpacking Artificial Intelligence**.

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from jmc.stanford.edu/articles/whatisai/whatisai.pdf

Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority of them are focused on two general areas: automating administrative tasks, such as taking attendance and grading assignments, or increasing student performance through AI-supported assessment, personalized learning, and increasing engagement in typically mundane rote learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of this guide is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users and even creators of these powerful tools.

This guide is for educators who teach core academic subjects in grades 6–12. Why devote a guide to these areas of study? Once the stuff of science fiction, AI now permeates nearly every facet of our lives, and while most of us are aware of tools like virtual assistants or navigators, we may not be cognizant of ways that AI is impacting society. For example:

- As the field of AI expands, it is critical that students are aware of the ethical and societal implications of AI systems and how they are designed and regulated.
- AI-supported tools that are used to create and distribute information—both factual information and disinformation—challenge students to become increasingly sophisticated consumers of media.
- The use of chatbots and virtual assistants to support learning and productivity across content areas requires that students understand what these AI agents are and how they work.
- The use of AI for solving problems related to science and the environment calls for students to investigate how this is accomplished.

These examples point out the importance of all students understanding the degree to which AI is being used to influence what and how we learn, consume media, and solve problems. Awareness at this level does not require specific technical expertise. Educators with little or no prior experience with AI may still help their students become more informed about AI technologies. Educators can help by identifying instances of AI use, exploring the ethics of machines influencing decisions we make, and understanding enough about AI concepts that they can remind students that AI is a tool created by humans.

Until recently, conventional wisdom has suggested that instruction about AI should be confined to computer science courses at the high school level and above. However, the use of AI is becoming so pervasive throughout society that a basic understanding of what AI is and what its capabilities are is becoming as necessary as more traditional literacy skills like reading, writing, and computation. The Department of Homeland Security is strongly urging airports to implement facial recognition software to screen passengers. AI tools are being used to generate information in various formats—text, video, audio, and images. How can the consumer decide if this information is reliable versus meant to mislead? Virtual assistants and chatbots are becoming so realistic that it is sometimes difficult to

distinguish between them and humans. Medical experts and scientists are exploring the use of AI to recognize and diagnose diseases. Each of these examples emphasizes that, while most of the people who design these tools will likely be coming from math, science, and computer science disciplines, we are all end-users and therefore must be participants in the conversation if these tools are to effectively meet our needs.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach

The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their understanding of how AI technologies work, and create various authentic products– from chatbots to prototypes– to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the standards, concepts, and depth that would be appropriate to the core academic subjects in grades 6–12. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education, exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in computer science or AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, Project 3: Using AI to Solve Environmental Problems can be completed by students in science or English language arts courses in either middle or high school; however, instruction regarding machine learning and classification algorithms should deepen as they get older. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI (shown in Figure 1).

The Five Big Ideas in AI serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

THE FIVE BIG IDEAS IN AI

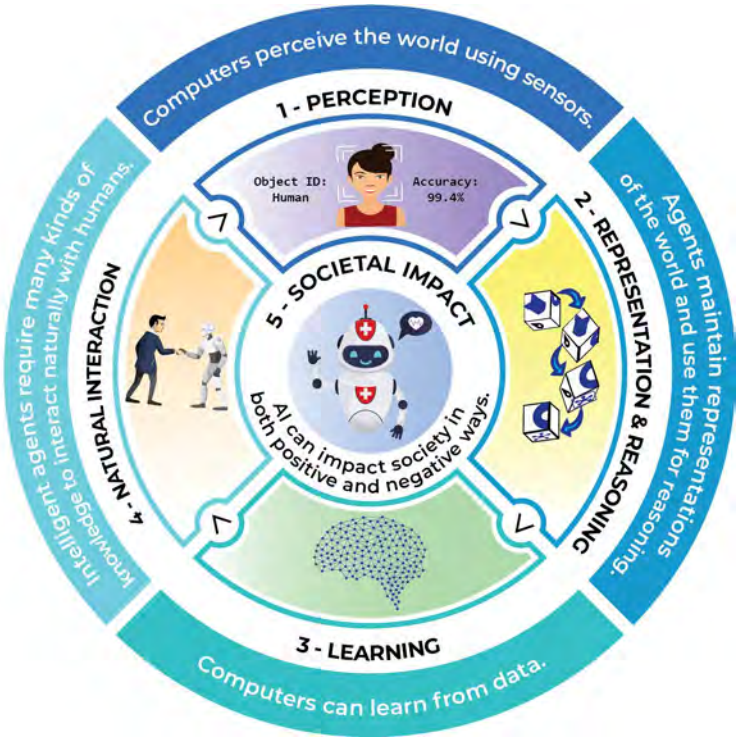

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution, Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities, or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both online and offline that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendices. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the *Hands-On AI Projects for the Classroom* series
- A discussion entitled "What Is AI?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows.

Project Overview

The project overview offers an explanation of what the project is, how it ties to research-based standards, and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject, target grades, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, ISTE Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

Preparation provides the information educators need in order to put the project into action with students. This section includes a list of materials required for project completion; a list of supporting resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools, reviewing online resources, etc.

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.
- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject area content.
- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE. ISTE does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Glossary and Appendices

Glossary

The glossary includes definitions for terms found in the projects that may be unfamiliar or need explanation for students.

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in all four guides in the *Hands-On AI Projects for the Classroom* series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1
AI Chatbots

While people might once have associated AI with robots or chess playing, today's students often interact with AI chatbots on a daily basis. AI chatbots like Siri, Alexa, Cortana, and Google Assistant are commonly found on students' smartphones, computers, and home devices, but how much do students know about how they work and how they can be used?

Project Overview

In this inquiry-based project, students will learn how AI uses natural language processing to converse in a human-like way, then apply this knowledge to develop a model for how an AI virtual assistant or conversational agent might perform a task related to their subject area coursework.

> We want our students to have an understanding of AI and how it works before they leave middle school, so we are developing a scope and sequence for teaching AI to them. Most students are familiar with chatbots, so this AI chatbot project would fit nicely as a way to start introducing them to AI.
>
> — **Julie Snyder, Technology and Engineering Teacher, Mellon Middle School**

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

5–7 hours

TARGET GRADES

6–12

VOCABULARY

chatbot
conversational agents
extract
natural language processing
sensor
virtual assistants

OBJECTIVES

At the end of the project, students will be able to:

- Explain what natural language processing is.
- Compare and contrast the strengths and weaknesses of virtual assistants and conversational agents.
- Explain how a virtual assistant or conversational agent can be used to perform subject area tasks.

STANDARDS

ISTE Standards for Students

2. Digital Citizen

d. Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.

5. Computational Thinker

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

6. Creative Communicator

c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

ISTE Computational Thinking Competencies

1. Computational Thinking

e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. Equity Leader

e. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

AI4K12 Five Big Ideas in AI

1. Perception

Computers perceive the world using sensors.

4. Natural Interaction

Intelligent agents require many kinds of knowledge to interact naturally with humans.

5. Societal Impact

AI can impact society in both positive and negative ways.

Content Area Standard(s)

This project has been designed for implementation in a variety of secondary classrooms. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other modern advances in that field.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Teacher computer and projector.
- Tool: Botframe

SUPPORTING RESOURCES FOR EDUCATORS

- Video: "Natural Language Processing #7"
- Article: "A Simple Introduction to Natural Language Processing"
- Video: "How do Chatbots work? Simply Explained"
- Article and video: "What are Chatbots?"
- Article: "How to Design a Voice Experience"

ADVANCED PREPARATION

Test out each of the chatbots students will be using and confirm that they will run both on student devices and the school network.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students activate prior knowledge on the topic of AI chatbots through class discussion.

1. Give students the definition of a **chatbot**: a software program that simulates conversation with a human. Simple chatbots can interact with humans using predetermined questions, answers, and statements that are coded into their programming. More advanced chatbots use AI for additional features like speech-to-text, text-to-speech, processing large vocabulary or knowledge bases, and learning from past conversations.

2. Ask students: Have you ever used an AI chatbot like Apple's Siri, Amazon's Alexa, Microsoft's Cortana, or Google Assistant? What did you use it for? What tasks did it perform? How was talking with the AI agent similar to talking to a human? How was it different? Have you ever been unsure if you were talking to a human or a chatbot?

TAKE A CLOSER LOOK

Activity 2: Experimenting With AI Chatbots

In this inquiry-based activity, students will interact with two types of AI chatbots: virtual assistants and **conversational agents**. They will discuss the strengths and weaknesses of each form of chatbot.

1. Tell students that in this activity they are going to learn about two types of AI chatbots: virtual assistants and conversational agents.
2. Have students interact with and watch the demos of several virtual assistants and conversational agents. You can use the ones listed below or supplement this list with examples of chatbots related to your specific subject area. As they interact with each chatbot, students should ask it to complete several basic tasks, such as booking an appointment, setting a timer, or calculating a math problem; and also try to hold a conversation with it about several everyday topics like hobbies or thoughts about the world.

   > **NOTE:** Since the data entered is sent out to be processed by the AI, students should not offer any personally identifiable information.

   - **Watson Assistant's BankBot**: This virtual assistant helps process banking transactions.
   - **Cleverscript virtual assistant**: This virtual assistant can answer questions about maps, definitions, translations, and calculations.
   - **Google Duplex**: This video demonstrates a virtual assistant that performs tasks using human-like communication.
   - **Eliza, the Rogerian Therapist**: The original version of this chatbot was one of the first conversational agents mistaken for being human in the 1960s.
   - **A.L.I.C.E.**: This conversational agent won several awards in the 1990s.
   - **Mitsuku**: A recent award-winning conversational agent.
3. Display a blank Venn diagram. Write "virtual assistant" in one circle and "conversational agent" in the other. Ask students to reflect on their interactions with the chatbots and identify characteristics that the virtual assistants and conversational agents have in common and those that differ. Possible answers include:

   Virtual assistants. Follow directions to perform discrete tasks, such as managing to-do lists, taking notes, setting timers or appointments, or looking up information. Have access to a knowledge base and can only answer questions about that information. Often used for customer service. Serve a specific purpose.

   Conversational agents. Natural, human-like interaction. Asks questions and talks about a wide variety of topics, even personal ones. Can make small talk.

Both. Able to recognize human language. Able to hold a conversation. Limited or no understanding of topics beyond their knowledge base. Ask questions of the user. Cannot always recall what they already said. Don't always make sense.

4. Conclude the activity by sharing these definitions to summarize what they've learned.
   - Virtual assistant: an AI software agent that performs specific tasks based on a user's commands or questions.
   - Conversational agent: an AI software agent designed to have a natural dialogue with a user.

Activity 3: How Does a Chatbot Work?

In this activity, students will take a deeper look at how chatbots work. Students will consider how the quality of an AI's **natural language processing** (NLP) affects its ability to interact naturally with humans.

1. Project these two videos about chatbots: "**What is a chatbot and how does it work?**" and "**The Turing test: Can a computer pass for a human? —Alex Gendler**."
2. Reinforce the following concepts, based on the content of the videos:
   - AI chatbots are powered by natural language processing.
   - Natural language processing is the AI technology used to understand and interact with human language.
   - Natural language processing powers technologies like voice experiences and assistants, text predictors, grammar checks, and language translators.
   - To perceive and understand what people are saying, the AI uses **sensors** to receive input.
   - The AI must decipher sounds, syntax, semantics, and context to **extract** meaning.
   - To appropriately respond, the AI must be able to generate coherent sentences.
3. Ask students:
   - Based on your interactions with and observations of AI chatbots, how well do you think they are doing at simulating human conversation? As chatbots become more human-like, what might be the ethical considerations of telling or not telling people that they are communicating with an AI?
   - Why do you think some chatbots do a better job than others? How might chatbots benefit from combining the abilities of both virtual assistants and conversational agents into one AI entity?
   - What might be the benefits of using chatbots in homes, schools, or businesses? What might be the challenges or risks?
   - Do you think it is important for everyone to have a basic understanding of how AI chatbots work? Why or why not?

CULMINATING PERFORMANCES

Activity 4: Design an AI Chatbot

In this culminating performance, students will create a model of an AI chatbot application within your subject area or class.

1. Divide students into groups of 2–4. Have each group brainstorm a list of at least 3 ways that an AI chatbot might be used in your subject area or class. While students might imagine AI chatbot applications like those in science fiction, encourage them to work within the current capabilities of AI chatbots, which typically serve a specific, narrow purpose and are limited by the strengths and weaknesses of natural language processing. For example, an AI chatbot might help quiz students while they study for a test, retrieve definitions for vocabulary while the student reads a short story, make calculations while students perform a science experiment, conduct a poll in a social studies class, comfort students when they are feeling anxious, or schedule parent-teacher conferences. If you would like students to create chatbots as a culminating project for a unit, you can tell them to brainstorm applications related to that unit's content, such as figurative language, the civil rights movement, the periodic table, or converting measurements.
2. Next, have each group select one of their ideas to develop further. Students should use a planning tool like **Botframe** to create a model demonstrating how their chatbot would work, and prepare to present it to the class. Remind students to think about the realistic strengths and weaknesses of an AI chatbot's natural language processing and make sure to reflect that in their model and presentation. Depending on the amount of time you allot for this project, you might have students present an explanation or walk-through of their model by acting out a commercial that advertises their chatbot application. When presenting the commercial, students might simply read the script during their performance or they might be encouraged to consider costumes, props, or memorizing their lines.
3. Conclude the activity by having students present their models or perform their commercials for the class.

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on the societal impact of AI chatbots:

- How realistic do you think the AI chatbot applications you imagined in your presentations (or commercials) are? Which chatbot do you think would be the most beneficial to humans, and why?
- When you interacted with the online chatbots, you were told not to enter any personally identifiable information. What might be some of the privacy concerns when using chatbots, either for personal reasons or for tasks related to this subject area?
- How might you decide when the convenience of using a chatbot outweighs the privacy risks?
- What advice might you give to people about using AI chatbots to help perform tasks at home, school, or work?

Extensions

Following are two ways to expand students' exploration of AI-powered chatbots:

1. Students who want to learn to make their own chatbot using professional AI tools can participate in the Cognitive Class "**Build Your Own Chatbot**" course. This 5–6 hour online course teaches students about basic concepts of chatbot design and how to create a virtual assistant chatbot with Watson Assistant. No coding is necessary for the course. You can learn more about this and other IBM offerings about AI on their Primary and Secondary Education **Resources** page.
2. Students can create voice experiences for the Alexa chatbot through the user-friendly **Alexa Skills Blueprint** platform and the online **Echo simulator**. Alexa skills are individual apps or tasks that the chatbot is programmed to perform. Skills blueprints include a variety of formats, from sorting games to quizzes to storytelling.

> **NOTE:** These tools require Amazon accounts and may collect students' data. Please check their terms and conditions of use and children's privacy policy against your school/district student data privacy policy to insure the applications comply with that policy. In addition, the applications may require parental permission to be COPPA and FERPA compliant for students younger than 13 years of age.

PROJECT 2

Developing a Critical Eye

What does it mean to be a discriminating consumer of information in the age of AI? According to a report published by the Pew Research Center, "Experts are evenly split on whether the coming decade will see a reduction in false and misleading narratives online. Those forecasting improvement place their hopes in technological fixes and in societal solutions. Others think the dark side of human nature is aided more than stifled by technology.[1]" The solution to these challenges lies with understanding how AI is being used to create and distribute disinformation. This understanding also requires focusing on critical thinking skills and increased focus on information literacy.

Project Overview

In this project, middle and high school students will be challenged to learn about several AI-supported tools that are used to create and/or distribute information—both reliable information and disinformation. Class members will work in pairs or small groups to identify important topics in the news, and design 1–2 page plans describing how AI-supported tools could be employed to create and disseminate information campaigns, using both reliable information and disinformation, on those topics. Student teams will share their plans with the class.

> I think this could be a powerful project for language arts and social studies teachers to collaborate on. For example, using it in a civics course where students are examining how technology plays a role in policy-making.
>
> — **Lynn Erickson, Instructional Technology Specialist, Stafford Public Schools**

SUBJECT

English language arts
with cross-curricular Extensions.

ESTIMATED DURATION

10–12 hours

TARGET GRADES

8–12

1 Pew Research Center, October, 2017, "The Future of Truth and Misinformation Online"

VOCABULARY

artificial intelligence
bot
deepfake
disinformation
generative adversarial network (GAN)
misinformation

OBJECTIVES

At the end of this project, students will be able to:

- Identify and explore ways information, both reliable information and disinformation, is created and distributed through use of AI-supported tools including, but not limited to, deepfake videos, distorted images, audio recordings, and bots.
- Select topics in the news and develop 1–2 page plans for AI-supported information campaigns, using either reliable information or disinformation, on those topics.
- Evaluate and offer constructive feedback on AI-supported information campaign plans developed by other student teams.

STANDARDS

ISTE Standards for Students

3. Knowledge Constructor

b. Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.

d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

6. Creative Communicator

d. Students publish or present content that customizes the message and medium for their intended audiences.

ISTE Computational Thinking Competencies

1. Computational Thinking

e. Recognize how computing and society interact to create opportunities, inequities, responsibilities and threats for individuals and organizations.

2. Equity Leader

b. Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.

e. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

AI4K12 Five Big Ideas in AI

3. Learning

Computers can learn from data.

4. Natural Interaction

Intelligent agents require many kinds of knowledge to interact naturally with humans.

5. Societal Impact

AI can impact society in both positive and negative ways.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.RI.6.1 through RI.11-12.1: Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA-LITERACY.RI.6.6 through RI.11-12.6: Determine an author's point of view or purpose in a text and explain how it is conveyed in the text.

CCSS.ELA-LITERACY.RI.6.8 through RI.11-12.8: Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.

CCSS.ELA-LITERACY.W.6.1 through 11-12.1: Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-LITERACY.W.6.2 through 11-12.2: Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

CCSS.ELA-LITERACY.W.6.4 through 11-12.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCSS.ELA-LITERACY.W.6.8 through 11-12.8: Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Writing materials: paper, pens, pencils.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Artificial Intelligence and Disinformation"
- Article: "Dating apps need women. Advertisers need diversity. AI companies offer a solution: Fake people"
- Article: "Deepfake Video and Audio Recordings"
- Article: "How Google's search algorithm spreads false information with a rightwing bias"
- Article: "MIT made an AI that can detect and create fake images"
- Article: "State of Art Computational Propaganda"
- Article: "This stance-detecting AI will help us fact-check fake news"
- Article: "Using artificial intelligence to expand fact-checking"
- Article: "Weapons of Mass Distraction: Foreign State-Sponsored Disinformation in the Digital Age"

ADVANCED PREPARATION

Familiarize yourself with all the resources and tools listed in the instructions. Ensure they will work on the school network. If any are blocked, try to find a substitute, or request to have them unblocked.

Post the link to the article and video, "Dictionary.com's 2018 Word Of The Year Is …" and to the AI-supported tools listed in Activity 2 so students have access to them.

Instructions

GETTING STARTED

Activity 1: Introduction

In this activity, students will read an article and work in pairs/trios to compare and contrast the terms **misinformation** and **disinformation**. They will then engage in a conversation about AI and disinformation, including how disinformation is generated and distributed on social media platforms.

1. Ask students to think about what sources people use when they want to gather information about a topic that's new to them. Responses will vary, but may include print material like reference books or magazines as well as digital media like instructional videos, podcasts, and online reference materials consisting of text and images.
2. Introduce students to **AI** and AI-generated media. Key points should include:
    - A description of what AI is, and that people across all fields are using AI to create informational text, images, video, and audio. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.

- Tell students that Dr. Melvin Kranzberg was a professor of the history of technology at the Georgia Institute of Technology. Dr. Kranzberg developed Six Laws of Technology. The first law states: "Technology is neither good nor bad; nor is it neutral." What he meant by this is that while in and of itself, technology is not good or evil, it does lead to unintended consequences. For example, the people who developed AIs that can write articles good enough to publish did not necessarily anticipate that someone might use these tools to flood the internet with misinformation and disinformation. Unreliable information generated with AI tools is often difficult to differentiate from accurate information.
- Tell students that as they complete this project they will learn how people use AI-powered tools to create and distribute misinformation and disinformation. This project will help them improve their skills at evaluating the quality of information.

3. Have students pair up or form trios. Distribute paper and ensure students have pens/pencils. Ask them to each individually draw a table with three columns. Label the column on the left "Misinformation—Differences." Label the middle column "Misinformation & Disinformation—Similarities." Label the column on the right "Disinformation—Differences." Ask students if they have heard the terms misinformation and disinformation. Direct their attention to the link to "**Dictionary.com's 2018 Word Of The Year Is …** ." Ask them to read the article individually and add notes to the table they drew in the correct columns. If possible, have students watch the video that is embedded on the article page on their own as well, but if necessary, show the video to the entire class after they have read the article. Give student pairs/trios a few minutes to compare the notes they took individually and identify how the terms are similar and how they differ. Engage students in a class discussion about their findings. The critical point they need to understand is that misinformation and disinformation differ in one critical way—misinformation relates to incorrect information that is shared in the belief that it is true while disinformation is incorrect information intentionally shared to mislead.
4. Ask the class to brainstorm a list of ways they think AI might be used to create disinformation. Post the list where all students can see it. Explain that there are several common ways AI is used for this purpose, including AI-generated text, images, video, and audio. Project the following links to show students examples of each type of AI-generated artifact:
   - **Catching a Unicorn with GLTR**: A tool to detect automatically generated text: Take time to discuss each example with the class. When reading the AI-generated text, ask students: Does it make sense? Why or why not?
   - **Which Face Is Real?**: Which Face Is Real? challenges viewers to look closely at each image and decide if it is a real person or AI-generated. Allow students to look at several pairs of photos and guess which one in each pair is a real person.
   - **Fake Obama Created Using AI Video Tool**: The Obama video shows a sample **deepfake** and offers a quick overview of how it was generated (1:26).
   - **Voice Cloning Experiment**: This voice cloning site provides several very short audio samples of a person's voice. Those voice samples are then used to create a statement made in the same voice that is completely AI-generated (the listing in bold type is the best example in each voice sample).

5. Explain to students that these AI-supported technologies are sometimes used to create disinformation. Ask them to consider why this might be problematic. Also ask if the same tools could be used to support the creation of accurate information. Can they identify situations where the answer might be yes and other times when the answer might be no? Answers will vary, but might include: AI-generated text could be fact-based depending on how the AI was trained; the ethical use of AI-generated images would depend on how the images are presented; deepfake videos might be used in harmless ways, but most are not; and there are benign ways AI-supported voice-generated clips could be used, such as dubbing over a mistake in a recording.
6. Now have students brainstorm a list of ways AI might be used to spread information and disinformation across the internet. Again, post the list in a place where it can easily be seen by students. Mention that some common ways used to spread information and disinformation include targeted marketing (specifically identifies narrow audiences for various kinds of information and disinformation), search engine optimization (helps push information and disinformation to the top of search results), and **bots** (automate the sharing of information and disinformation to reach millions of targeted consumers). Share the following examples of information distribution methods.
    - In an example of targeted marketing, Cambridge Analytica, a political consulting group, illegally acquired data belonging to 87 million Facebook users. The data were collected from Facebook users who took an online quiz, but Cambridge Analytica also took data that belonged to the Facebook friends of the person who took the quiz. The data were used to distribute disinformation to specifically targeted audiences.
    - Researcher Robert Epstein of the American Institute for Behavioral Research and Technology conducted a study where he found that Google's search algorithms and personalization of search results—which means different users see different search results—results in biased search results that impact people's opinions about issues.
    - During the final hours before the 2017 presidential election in France, Emmanuel Macron's email account was hacked. Right-wing activists, bots, and automated accounts took the stolen emails, which were housed on an obscure site, and made them a worldwide issue within hours through mass circulation.
7. Ask students why the use of information distribution tools was problematic in these examples. Then ask if the same distribution tools can be used to spread accurate information. After giving them a few minutes to share their ideas, tell students that during the next two activities in this project they will learn more about how AI can be used to create and distribute information and disinformation.

TAKE A CLOSER LOOK

Activity 2: Creating Information and Disinformation Using AI

In this activity, students will explore hands-on examples of ways that AI-supported online tools can be used to create various types of information and disinformation.

1. As a review, ask students to identify the four common ways AI-supported tools can be used to generate information and disinformation that were specified in Activity 1. You may need to remind them that the categories were: text, images, video, and audio. Have students regroup into their pairs or trios from Activity 1. Explain that during this activity they will learn more about AI-supported online tools that can be used to create various forms of information and disinformation.

2. Ask students to work in their pair or trio to explore the following list of AI-supported tools and write a brief review of each category: text, images, video, and audio. Their review should include:
   - How each tool can be used to generate information and disinformation.
   - What they see as being strengths and weaknesses of these tools.
   - Whether the products created by these tools appear to be genuine, or if there are obvious clues that a product might not be trustworthy? Point out that AI-generated text may not make sense, even when it's factually accurate; AI-generated images may not "look right" (e.g., missing ear, odd hairline); deepfake videos also may not "look right" (e.g., mouth and audio out of synch); and AI-generated audio may sound robotic in terms of fluency and pronunciation.
3. Following are the AI-supported tools students will explore:
   - Text: **Story Generator**. Let an AI write a story for you.
   - Text: **Write with Transformer**. Write a few sentences and let an AI generate a new paragraph for you.
   - Text: **Chatbot**. Converse with a chat bot.
   - Image: **GAN Paint Studio**. See how photos can be manipulated using a Generative Image Prior.
   - Image: **This Person Does Not Exist**. View images of faces created with a **generative adversarial network** (GAN).
   - Image: **Generated Photos**. View a gallery of faces created with a GAN.
   - Video: **Deepfake Videos Explained**. View a CBC Kids News spot featuring deepfake videos.
   - Video: **AI Brings Mona Lisa to Life**. Watch as the Mona Lisa appears to talk.
   - Video: **Samsung's new AI technology brings photos to life**. See an overview of several deepfake videos created by Samsung.
   - Audio: **Online Tone Generator**. Type a sentence or two, select a voice, and click play.
   - Audio: **Spik.AI**. Type a sentence or two, select a voice, and click play.
   - Audio: **Watson Text to Speech Demo**. Type a sentence or two, select a voice, and click play.

Activity 3: Disseminating Information and Disinformation Using AI

In this activity, students will research ways AI-supported distribution strategies are used to spread information and disinformation.

1. Remind students of the brief class discussion that took place during Activity 1, which focused on three AI-supported distribution strategies: targeted marketing, search engine optimization, and bots. Explain that in this activity students will work in teams to investigate one of these distribution strategies, focusing on how the strategy works and ways it might be used to distribute information and disinformation. Teams will then share this information with classmates.

2. Divide the class into six groups of equal size. Assign one distribution strategy to each team, so that each strategy is being researched by two teams. Explain to students that each team will have one class period to research its strategy and one class period to prepare an information sheet about the strategy. The information sheet could be in the form of a hardcopy or digital handout, flyer, poster, or infographic, and should include the following:
    - Name of strategy
    - Definition of strategy
    - Explanation of how the strategy is used to distribute information, including the role of AI
    - Explanation of how the strategy is used to distribute disinformation, including the role of AI
    - Summary of the pros and cons of using this strategy to distribute this information
3. Each team will share its one-page information sheet with the class. Teachers may distribute copies of these information sheets to each team or post these documents online for the whole class to access.

CULMINATING PERFORMANCES

Activity 4: Brainstorming Topics for Campaigns

In this activity, student teams will create plans for informational campaigns using AI-supported tools to create and disseminate information that is either accurate or disinformation (one-half of the campaigns are based on accurate information and one-half on disinformation). While completing the activity, students will conceptually explore real-life applications of AI tools used to inform or disinform consumers. When teams' completed campaign plans are shared, students will discuss each plan to decide which are most compelling and why. Students should not actually create or launch the campaigns. Students may use the tools previewed in Activity 2 or other appropriate options.

1. Ask students to brainstorm a list of issues that are currently in the news. Create a class list of the topics mentioned by individual students. Select one from the list to use as a model. For example, let's say that a student mentioned scientists' concerns about disappearing permafrost. Explain to students that melting permafrost is measurable and undeniable. There are scientific explanations about why this is happening, but there are also people who deny the explanations. Tell students that for this assignment, one class team will plan an online campaign that uses AI-supported tools to identify or create and distribute factual information about melting permafrost, while another team will plan an online campaign that uses AI-supported tools to identify or create and distribute disinformation about melting permafrost. Model the process for brainstorming a plan for the accurate information campaign using the following steps:
    - Remind students that they explored four kinds of content that can be created using AI-supported tools: text, images, video, and audio. Say they will use a mind map to create an initial outline. Write the main idea, "The World's Permafrost Is Melting" in the center of the mind map. Draw four main topic circles or rectangles that connect to the main idea. Label them: text, images, video, and audio. Model brainstorming the specific kinds of text, images, videos, and audio (e.g., articles, photographs, video clips, or podcasts) that could be used to support the main idea. Add these ideas to the mind map, connecting them to the main idea.

- Say that they will be distributing the information online. Brainstorm ideas for ways this material could be formatted for online distribution, such as social media posts, an online poster, or a website. Add these to the mind map, linking them to indicate which format could be used for each specific kind of text, image, video, or audio. (There may be more than one format option for each.) An example mind map is shown in Figure 2.

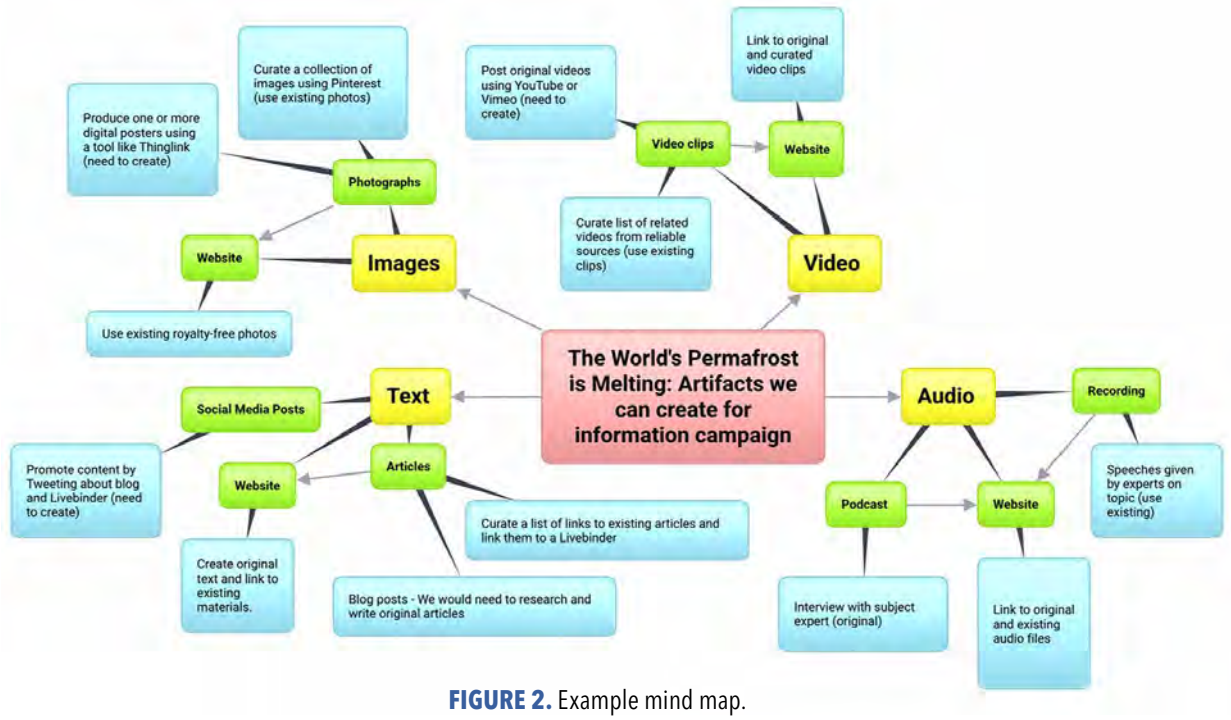

FIGURE 2. Example mind map.

- Ask students if they would need to create all content on their own, or if they would be able to find existing material like articles, images, video, or audio clips that they could fact-check and use as a source of information for the campaign. Mark each specific type of content on the mind map either "use existing" or "need to create." In the course of the conversation, help students conclude that in this example they would probably need to research and write social media posts, use an online tool like **Thinglink.com** to create an online poster, and create some content for a website if they decided to build one, but they could also probably use existing images, video, and audio if they conducted an online search to find copyright-free material that they could fact-check.
- Tell students that for the purposes of this example, they should imagine creating an online poster to share factual information about melting permafrost, and promoting the poster through social media. The AI-supported distribution methods they will use are search engine optimization and bots.
- Point out that the mind map they've created can now serve as a draft outline for their information campaign. Point out that if they were assigned the disinformation campaign for this project, they would

need to create more of the content, because it might be difficult to find existing text, images, videos, and audio that denies that the permafrost is melting. In that case they would need to generate text, alter images, and possibly create a video or fabricate an audio clip of someone claiming that the permafrost isn't melting. Brainstorm what kinds of tools could be used to create faked content.

- Tell students that the final step for their project will be to take the mind map they've created and create a 1–2 page proposal for the campaign. The proposal needs to include all the elements in the mind map: title; types of content; format(s) for content; sources of content (existing, or created for this purpose and how); and how the information or disinformation will be distributed.

2. Choose three topics from the list brainstormed by students. Divide the class into six teams. Assign two teams to each of the three topics—one team will design an information campaign and the other a disinformation campaign. Answer any questions students have. Remind students that they are not actually creating or launching these campaigns. Instead, they are to use what they have learned to create a presentation about their plan to the class.
3. Give the teams two class periods to create the mind map and a 1–2 page proposal for their campaign.
4. Teams should make brief (10-minute) oral presentations of their proposals, during which teams should pitch their proposals without identifying them as accurate information or disinformation. The class should critique each proposal, stating which they find most compelling, which they think are based on accurate information, and which they think are based on disinformation, and why. At the conclusion of the presentations, be sure to reveal which campaigns were information and which were disinformation.

Activity 5: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of using AI.

- What did you learn about AI-supported tools that can be used to create content? What are some of the pros and cons of having an AI generate content instead of a person?
- What did you learn about AI-supported tools that can be used to distribute content online? What are some of the pros and cons of having an AI distribute content instead of a person?
- How will you apply these skills to avoid being misled when you use social media or other online resources?

Extensions

Here are four ways to expand students' abilities to recognize factual information and disinformation:

1. Extend this project into other subject areas by looking at content-specific topics. For example, a civics class might develop campaigns based on government policies, while a health class might develop campaigns focused on diets.

2. **GROVER** is a machine learning model that is both a generator and discriminator of fake news created by AI. A generator is an AI able to produce believable fake news stories. A discriminator is able to analyze news stories to determine if they were written by an AI. When students use a critical eye to analyze media to determine if it is disinformation, they are also acting as discriminators. For this extension, students should read more about GROVER on the website; use GROVER to generate fake news stories and see if they are able to find characteristics in the articles that can help them discriminate between news written by a human or by an AI; and use the "detect" feature to test GROVER's ability to correctly identify news stories as written by a human or an AI.
3. CNN has created an interactive page called "**When Seeing Is No Longer Believing**." Work through the content and activities presented here as a class or have student teams review the page. Topics include:
   - What are deepfakes?
   - Can you identify deepfakes?
   - A history of video manipulation.
   - How are deepfakes different from genuine media?
   - Many more topics are covered.

   Have students break into small groups to discuss what they learned during this activity and how they will apply this information.
4. Why is fact-checking critical? Persistent repetition of misinformation and disinformation leads many people to believe something is true, even when it is not. Watch this brief video with your students: **The Easiest Quiz of All Time**. It illustrates why it's important to fact check even things we're quite sure about. Discuss students' reactions to the video and brainstorm a list of fact-checking tips and resources they can use.

PROJECT 3

Using AI to Solve Environmental Problems

Project Overview

Environmental projects, whether protecting endangered species or addressing global climate change, are important to many students and also to many AI developers. In this project, students will try out an AI-powered application designed to address an environmental challenge, explore several AI projects aimed at sustainability and environmental protection, and propose an AI-powered solution to a local environmental problem they identify.

> At a time when students often feel overwhelmed by anxiety for the health of our planet, this project affirms that AI is one of the extraordinarily powerful tools we can all use to help save the earth.
>
> — **Anna Clarke, Lead Teacher, Lakeland Montessori Middle School**

SUBJECT

Science and/or English language arts

TARGET GRADES

6–12

ESTIMATED DURATION

10–12 Hours

VOCABULARY

artificial intelligence
classification algorithm
features
machine learning
training data

OBJECTIVES

At the end of the project, students will be able to:

- Describe how AI is currently being used to solve real-world environmental problems.
- Develop a presentation on how AI might be used to help solve a real-world environmental problem that they identify.

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.
3. **Knowledge Constructor**
   - d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.
4. **Innovative Designer**
   - a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
5. **Computational Thinker**
   - a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
7. **Global Collaborator**
   - d. Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.

ISTE Computational Thinking Competencies

1. **Computational Thinking**
   - b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.
2. **Equity Leader**
   - e. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.
3. **Collaborating Around Computing**
   - a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.
5. **Integrating Computational Thinking**
   - b. Empower students to select personally meaningful computational projects.
   - c. Use a variety of instructional approaches to help students frame problems in ways that can be represented as computational steps or algorithms to be performed by a computer.

AI4K12 Five Big Ideas in AI

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.
3. **Learning**
   Computers can learn from data.
5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Next Generation Science Standards

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

CCSS.ELA-LITERACY.WHST.9-10.7/11-12.7: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Preparation

MATERIALS

- Student mobile devices with internet access (1 per student or group).
- Teacher device and projector.
- Listed online articles, tools, and resources.
- Sticky notes and writing utensils.
- App: **Seek by iNaturalist** and **iNaturalist User Guide**

> **NOTE:** iNaturalist, which is used in this project, offers a web-based alternative to Seek by iNaturalist that can be used by students aged 13+. The reason for mentioning the age restriction here is that the Seek by iNaturalist mobile app does not require students to set up a personal account, but the web application does.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Artificial Intelligence—A Game Changer for Climate Change and the Environment"
- Resource: iNaturalist Computer Vision Explorations
- Guide: Using AI for Social Good
- Resource: Oxford Initiative on AIxSDGs, a searchable collection of AI projects that address the United Nations Sustainable Development Goals. Some linked resources about the projects are in various languages. You and your students can translate these resources by inputting the URL for the resource into Google translate. Learn more.
- Resource: Microsoft's AI for Earth Initiative
- Article: "From Computational Thinking to Computational Action"
- Article: "What is Design Thinking and Why Is It So Popular?"

Instructions

GETTING STARTED

Activity 1: What Can AI Do?

In this activity, students will consider the capabilities of **artificial intelligence** by watching a video and completing an affinity diagramming activity. If students are unfamiliar with AI technologies, you may want to supplement the video in this activity with additional supporting resources, such as those found in Appendix A: Unpacking Artificial Intelligence.

1. Display the question "What can AI do?" on a whiteboard, bulletin board, or wall.
2. Give 3–4 sticky notes to each student. Project the first 06:33 minutes of the video "A planetary computer for Earth" or another video clip that provides an overview of how AI is being used to address environmental and sustainability challenges. As students watch the video, have them write down facts or ideas about what AI can do on the sticky notes. Each sticky note should list only one fact or idea.
3. After the video, have students place the sticky notes under the posted question. Work with students to organize the notes into categories by discussing how they might label different types of AI capabilities and examples. Then cluster their ideas using the categories they identify.
4. Tell students that in this project they will be looking at projects that use AI capabilities to positively impact environmental problems. Keep the sticky notes displayed and let students know they will return to this activity later in the project.

TAKE A CLOSER LOOK

Activity 2: Using an AI-powered Environmental Tool

In this activity, students will use an AI-powered tool, **Seek by iNaturalist**, to identify plants and animals in their immediate environment. The Seek by iNaturalist mobile app provides real-time computer vision for organism identification, while offering privacy safeguards for children of all ages including no required accounts and no collection of personally identifiable information. Students who are aged 13+ or who have a parent's permission can (optionally) log in with an iNaturalist account to share their observations with the greater iNaturalist community. If your class does not have access to iOS or Android mobile devices, students aged 13+ can create an account on the web-based iNaturalist platform to engage with its AI computer vision feature or to share their observations. The **Seek by iNaturalist User Guide** shows a comparison of the two platforms and provides instructions for the Seek Camera computer vision function.

1. Introduce students to the Seek by iNaturalist app and demonstrate how to use the Seek Camera computer vision function to identify organisms.
2. Explain to students that modern AIs use **machine learning** to quickly process large amounts of data (numbers, text, images, sounds), find features and patterns in those data, and perform a task, such as classification or prediction. In the Seek app, the AI uses a **classification algorithm** to identify the correct labels for the kingdom, phylum, class, order, family, genus, and species of a living organism in an image. While being trained, the Seek AI was given millions of images, along with their correct labels, as **training data**. The AI used those data to create a model of **features**—unique measurable properties—common to each species. The AI uses that model to classify new data samples with a label to a certain degree of confidence. In this app, as long as a species has at least 20 examples in the training data, it can now be identified correctly by the model most of the time. Plus, as members of the iNaturalist community add new observations of various species to the data set, the AI is able to identify more and more species.
3. Direct students to look at the image(s) you used in the demonstration. Ask them: What features do you think the AI identified in this image that helped it correctly classify this plant or animal? What features are unique to this species compared to others that are similar?
4. Have students use their mobile devices during class time or after school to identify 3–5 living organisms. Depending on their access to devices, they could do this as individuals or in small groups. (Please note: The iNaturalist database and application focuses on species that are naturally found in the wild and not placed there by humans. While students might use the app to identify garden plants, pets, or zoo animals, students should not upload observations of them to the iNaturalist database.)

5. Conclude the activity with a class discussion about students' experiences using this AI tool.
    - What was your experience like using this AI-powered tool?
    - What kinds of organisms did you find? Was the app able to correctly identify each of your photos all the way to the species? Did it identify any incorrectly? Was it unable to identify any of the organisms in your images? Why do you think it was sometimes more accurate and sometimes less accurate?
    - What might be the benefit of having an application that can correctly identify thousands of species around the world? How could an application like this be used to address environmental or sustainability challenges?

Activity 3: How AI Helps Solve Environmental Problems

In this activity, students will take their inquiry into the capabilities of AI further as they look into an environmental AI project. In the process, students will learn more about how AI works and the types of problems AI may help solve.

1. Have students work in groups of 2–4 to choose an environmental AI project to investigate. Students can choose from the projects listed below or explore projects listed by the **Oxford Initiative on AIxSDGs**, Google's **AI for Social Good**, or Microsoft's **AI for Earth**. If your students encounter resources in various languages when using the Oxford Initiative on AIxSDGs, they can try translating these resources by inputting the URL for the resource into **Google translate**.
    - **Bat Detective**: This classification project combines bat identifications made by human volunteers with machine learning to monitor bat populations. **Learn more**.
    - **Plant Village**: This program recognizes diseases in leaves and advises farmers about what steps to take to address them. **Learn more**.
    - **Carbon Tracker**: This project uses pollution data to predict which power plants will be profitable. **Learn more**.
    - **MILA's Visualizing Climate Change**: This project predicts how climate change might damage homes and other areas. **Learn more**.
2. Direct students to use the articles and other resources provided and/or their own research to learn about the project they select. Groups should try to answer the following questions and prepare a 3–4 minute presentation for the class.
    - Briefly summarize the project. What is the problem that is being solved? How is AI technology part of the solution?
    - What makes the problem difficult for humans to solve without AI assistance?
    - How does the AI in the project work? Does it use machine learning? If so, what type of data was it trained on and/or does it process?
    - Is this AI technology being implemented in an ethical way? Are the data collected without harming anyone or anything? What do people do with the information from this AI project? How might people misuse information from this AI project?
    - Do you think that AI is an appropriate tool for solving this problem?

3. Have each student group present their findings. As they do, have their classmates write down new facts or ideas about what AI can do on sticky notes. Again, each sticky note should list only one fact or idea.
4. Following the presentations, have students add any new sticky notes to the categories on the wall and briefly discuss the new AI capabilities or applications they discovered. Help students conclude that an AI's ability to outperform humans at tasks such as classification or prediction make it a useful technology in addressing many environmental and sustainability challenges.

CULMINATING PERFORMANCES

Activity 4: Proposing an AI Solution to a Community Problem

In this culminating performance, students will use a design thinking process to identify a way AI might be used to solve a real-world environmental problem. In addition to learning more about an environmental issue and potential uses of AI, students should also explore their own capacity for creating computational solutions to real world problems.

Divide students into groups of 2–4, then have them work through the 5 step design thinking process below.

1. Empathize. In this step, students will ask: What are the environmental or sustainability problems I notice in my community? How do these problems affect the people around me? Students might find inspiration in the United Nations' list of **17 Sustainable Development Goals**. They should identify one specific local environmental or sustainability challenge to explore further. Have students research the issue. Suggest interviewing people in the community who are affected by the situation to understand the issue better.
2. Define the problem. Students should synthesize their research and explain the problem in detail, including the ideal outcome of a solution that works.
3. Ideate. Have students imagine how they might solve the problem using AI. When developing their solution, students should consider the following questions:
   - What makes the problem difficult for humans to solve without AI assistance?
   - How would the AI in the project work? Would it use machine learning? If so, what type of data will it be trained on and/or will it process?
   - How does the AI fit into the larger solution to the problem?
4. Create a prototype. Have students create a multimedia artifact, such as an infographic, video, or slideshow, that includes diagrams or descriptions about how the AI would function in the proposed solution.
5. Test. In this step, students will share their solution, garner feedback, and identify possible improvements. While multimedia products will be shared with classmates, ideally students would also be able to share their idea with the community members who would be most impacted by the problem and possible solution. Students should ask them for feedback and advice about their proposed solution.

Finally, before turning in their final product, students should have time to consider the feedback, make revisions to their prototype, and think about whether they feel it would be worthwhile to take their project further (through work in the current course or through other means).

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the societal impact of using AI technologies to solve environmental problems:

- In what way do you think including an AI technology in your solution changed the way you approached solving the problem you identified?
- What ethical questions should a company or organization consider before trying to implement the solution you described? What unintended consequences might your solution cause?
- How do you think AI technologies will create and improve solutions to environmental and sustainability challenges?

Extensions

Here are three ways to expand students' exploration of AI and machine learning to solve real-world problems.

1. Students with computer science skills may want to create a working prototype of the AI-powered solution they imagined in their culminating performance. Students can use a tool like **Teachable Machine** or **Machine Learning for Kids** to train and test a model that could be integrated into a program or app.
2. **Wildlife.ai** is a charitable organization that uses AI to promote conservation and prevent extinction. Students can learn more about these real-world applications of AI on their website. Students can further extend their learning through a Machine Learning for Kids project that Wildlife.ai has developed called "Kiwi or Stoat." In this project, students train a machine learning model to distinguish between images of kiwis and stoats in the wild, then implement it in a Scratch program to successfully classify new images. Directions for the "Kiwi or Stoat" project can be found on the **Machine Learning for Kids** website.
3. **Zooniverse** asks citizen scientists to participate in research projects by identifying objects in images. The projects range from penguin conservation to identifying spiral galaxies from telescope data. Students can explore citizen science projects that use volunteers' input to train AI, such as Gravity Spy, Supernova Hunter´s Project, or Galaxy Zoo projects, without creating an account, or they can participate in projects with an account.

> I would use this project in my science class because it provides students with a meaningful opportunity to identify and develop potential solutions to real world problems that are significant to their community. It would be great for introducing students to scientific taxonomy and utilizing the engineering process.
>
> — **Jennifer Smith, Teacher, Monticello Middle School**

PROJECT 4
Laws for AI

In late 2018, employees at Amazon, Google, and Microsoft protested their companies' willingness to bid on contracts to provide AI and cloud computing services to the Department of Defense. These protests raised issues related to the role of ethics in the development of new technologies—AI in this case. But concerns about ethics and developing technologies are not new and definitely not confined to AI. For instance, during the early nineteenth century the Luddites destroyed textile machinery to save jobs. In the mid twentieth century, Isaac Asimov explored issues related to ethics and robotics. He suggested a framework for the behavior of those robots that had some autonomy.

Project Overview

In this project, students will begin their exploration of ethics and technology by researching the attributes of an ethical business; learn about Asimov's Laws for Robotics; explore the need for similar work in the field of AI today; and develop four original laws for AI.

> I'm excited about this project because it effectively connects literature, computational thinking, computer science principles and ethics together in a turnkey lesson plan. I would use this in my Language Arts class because students need to develop an awareness of the ethical issues surrounding the development of the ubiquitous technologies they use on a daily basis.
>
> — **Pam Amendola, English Language Arts Teacher, Dawson County High School**

SUBJECT

English language arts

ESTIMATED DURATION

5–6 hours

TARGET GRADES

6–12

VOCABULARY

artificial intelligence
artificially intelligent robot (AI robot)
autonomy
ethical
robot

PROJECT 4
Laws for AI

OBJECTIVES

At the end of this project, students will be able to:

- Explain how Asimov's Laws for Robots impact the portrayal of AI in the story "Runaround."
- Describe topics related to ethics and technology.
- Develop and justify four laws for AI.

STANDARDS

ISTE Standards for Students

2. Digital Citizen

b. Students engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

3. Knowledge Constructor

d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

6. Creative Communicator

c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

ISTE Computational Thinking Competencies

2. Equity Leader

b. Construct and implement culturally relevant learning activities that address a diverse range of ethical, social and cultural perspectives on computing and highlight computing achievements from diverse role models and teams.

d. Communicate with students, parents and leaders about the impacts of computing in our world and across diverse roles and professional life, and why these skills are essential for all students.

4. Creativity & Design

c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

AI4K12 Five Big Ideas in AI

5. Societal Impact

AI can impact society in both positive and negative ways.

Common Core State Standards for English Language Arts

CCSS.ELA-LITERACY.RL.6.2 through 12.2: Determine a theme or central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.

CCSS.ELA-LITERACY.W.6.2 through 12.2: Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

CCSS.ELA-LITERACY.CCRA.W.7: Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Preparation

MATERIALS

- Class set of Isaac Asimov's short story "Runaround."
- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**After 75 years, Isaac Asimov's Three Laws of Robotics need updating**"
- Curriculum: **An Ethics of Artificial Intelligence Curriculum for Middle School Students**.
- Article: "**Artificial Intelligence and Ethics**"
- Article: "**Beyond Asimov: how to plan for ethical robots**"
- Article: "**Do We Need Asimov's Laws?**"
- Article: "**Elon Musk says AI development should be better regulated, even at Tesla**"
- Article: "**Ethical Concerns of AI**"
- Article: "**How tech employees are pushing Silicon Valley to put ethics before profit**"
- Article: "**It's time to address artificial intelligence's ethical problems**"
- Article: "**Teaching Kids the Ethics of Artificial Intelligence**"
- Article: "**The Ethics of Artificial Intelligence**"
- Article: "**Top 9 ethical issues in Artificial Intelligence**"
- Article: "**Who's to blame when artificial intelligence systems go wrong?**"
- Article: "**Duplex shows Google failing at ethical and creative AI design**"

ADVANCED PREPARATION

- Read the short story "Runaround."
- Familiarize yourself with background information about why Isaac Asimov wrote the Three Laws of Robotics, and ethical concerns related to robotics and AI, by reading the articles listed in the supporting resources or conducting research on your own. Decide if you want to share any of the article links with students and if so, which ones.
- Preview the video "**What Does 'Ethical' Mean to You?**"

Instructions

GETTING STARTED

Activity 1. Discussion and Rapid Research

In this activity, students will participate in a discussion of what it means for individuals and businesses to behave ethically. They will complete a rapid research exercise to learn about businesses that are considered to be **ethical**.

1. Most students have a strong sense of fair play. How do they react when they believe they've been treated unfairly? What does it mean to behave ethically? Show students the video clip, "**What Does 'Ethical' Mean to You?**" Ask students to think about the question posed in the video. How would they answer? Volunteers may share their responses.
2. Ask students if they are aware of businesses or organizations that identify as being ethical. Can they name a business that is thought of as being ethical? Refer students to the **2020 World's Most Ethical Companies Honoree List**. Ask students to form pairs, select one business from the list (monitor selections so each business is chosen just once), and then do a quick research activity to learn why that business is considered ethical, what it is doing well, and where it can improve. Student pairs will then create a one-page document that names the business and provides the information listed in the previous sentence. Post the documents in an online class space or in the classroom for students to read and review.
3. Explain to students that in the remaining activities in this project they will be exploring topics related to ethics and technology. Mention that innovations in science and technology dating back 500 years or more have caused dramatic changes in people's lives. Many of these changes are to our benefit, but that's not always the case. It's important to think carefully not just about advancements that can and are being made in technologies, but also about the positive and negative impacts these technologies will have on our world. This project helps students become aware of ethical considerations related to new and existing technologies.

TAKE A CLOSER LOOK

Activity 2: Asimov's Laws for Robotics

In this activity, students will learn about Isaac Asimov's Three Laws of Robotics: what they are, why he developed them, and how he applied them in his writing.

1. Begin this activity by drawing a Venn diagram. Label one circle "Robots" and the other circle "Artificial Intelligence;" label the intersection "AI robots." Introduce students to the concept of **artificial intelligence**, explaining what AI is and that people across all fields are using AI to power decision making, problem solving, and automation. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence. Then, in the Venn diagram, have the class brainstorm a list of **robots**, both AI and non-AI, and place them in the correct spot in the Venn diagram. Examples of **artificially intelligent robots (AI robots)** include warehouse robots that navigate the warehouse, some delivery drones, or self-driving cars. Help students to understand that AI robots are able to make **autonomous** decisions.

2. To lay the groundwork for why Asimov developed the Three Laws of Robotics, watch the video clip "**Isaac Asimov: The Three Laws of Robotics.**" Ask students why Asimov thought the laws were necessary. Help them understand that while Asimov didn't intentionally set out to create laws for robots, what he wrote did provide a framework for the behavior of those robots with autonomy within his fiction. This is also a good time to point out that although AI isn't specifically mentioned in science fiction stories like those written by Asimov, the robots described often have a great deal of autonomy, demonstrating AI. As students discussed in the Venn diagram activity, in real life some—but not all—robots are AI robots, but even the AI robots that do exist do not have the high level of autonomy typically found in science fiction.
3. Read Isaac Asimov's short story "Runaround." Then hold a class discussion that explores the following key areas:
    - Discuss how the three original Laws of Robotics were incorporated into the story and drove the story's plot.
    - Mention that later, when Asimov expanded his stories to include fully autonomous robots that were responsible for governments and civilizations, he developed what he called the Zeroth Law of Robotics, which stated, "A robot may not harm humanity, or through inaction allow humanity to come to harm." Ask students: Why do you think Asimov thought this was important to add? What is an example of how, in the absence of this law, a robot might allow humanity to come to harm through inaction?
    - Ask students to consider how literature influences readers' views of the world around them. Bring up the following additional questions: Does science fiction always accurately describe the current capabilities of various technologies? How is technology actually impacting our lives? Do we need laws today that would create a framework for how AI is developed and used? Why or why not?

Activity 3: AI's Impact on Daily Life

In this activity, students will research real-life examples of some impacts AI is having on society.

1. Review students' responses from the previous activity to this question: What kinds of impacts is AI having on our society today? Have students work with 1 or 2 classmates to find 3–4 examples of ways that AI is changing our world.
2. Have students share the examples they find with the whole class. Ask them the following questions:
    - Do these impacts improve people's lives, or make them more difficult? Explain your thinking.
    - Which of your examples could be considered ethical uses of AI? Did these examples show use by individuals? Students? Educators? Companies? Governments? Other groups?
    - Did you find examples of unethical uses of AI? Did these examples show use by individuals? Students? Educators? Companies? Government? Other groups?
    - How can individuals, companies, and other groups be encouraged to always use AI ethically?

Activity 4: Laying the Groundwork for Laws for AI

In this activity, students will consider what would need to be included if Laws for AI were written.

1. Review Asimov's Laws of Robotics and why they were written. Revisit the class discussion during Activity 2, when students first considered if laws for AI are needed. Ask students if the work they did in Activity 3 changed or confirmed their thinking about the need for laws for AI, and why?
2. Students should form teams of 3–4 and brainstorm ideas that laws for AI would need to address, based on the **AI4K12 Five Big Ideas in AI**.
3. Have students share their ideas.

CULMINATING PERFORMANCES

Activity 5: Laws for AI

For the culminating performance, students will apply their thinking about ethical uses of AI and robotics as they write an expository piece about their own laws for AI.

1. Working in teams of 3–4, have each small group identify 4 issues from their discussion during Activity 4 that they think are most important to address in laws for AI. Give teams time to write a law for each issue and to develop a one-paragraph written rationale for each law. When students are satisfied with their work, they may create a digital poster of their laws using a tool like **Google Drawing**, **Google Slides**, **Easel.ly**, **ThingLink**, or something similar. Challenge them to devise a way to hyperlink the one-paragraph rationales to each individual law.
2. Have each team present its laws to the class.

Activity 6: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of using AI:

- What did you learn about ethical and unethical uses of AI?
- What kinds of issues do AI developers need to consider when developing new AI?

Extensions

Following are three ways to expand students' exploration of ethics and AI:

1. Remind students that Isaac Asimov used his Laws of Robotics to create plots for stories he wrote. Ask them to consider how they could use the laws of AI they created in their groups to develop a plot for a 2,500 word short story based on either an ethical or unethical use of AI. Have students work individually to write their short stories.
2. Explain to students that a scenario is a description of a series of events that may be real or imagined. These events usually focus on topics people care about deeply. Scenarios are typically used to help people reflect on how they would deal with the situation described. Remind students of the examples of ethical and unethical use of AI they found during Activity 3. Tell them they have an opportunity to develop 1–2 scenarios about ethical or unethical uses of AI that will be used to help other students think about important ethical questions. If your students need more concrete examples of what a scenario might look like, refer to the article "Top 9 ethical issues in artificial intelligence" listed above in Supporting Resources to create one or more sample scenarios. Have students develop 1–2 scenarios of 500 words each.
3. In this project students focused primarily on laws that protect humans from AI. Flip the conversation and ask students what might happen if humans intentionally sabotaged an AI? News stories about people jumping in front of a self-driving car to test its reflexes, feeding disinformation into a neural network to skew its results, or physically damaging AI-powered robots are becoming more common. It is unclear right now how these actions might negatively impact the effects of AI on our society or even our own mental health. Have students consider current events about incidents of this type and write a Public Service Announcement about a new law for AI that addresses how human misbehavior toward AI might lead to negative outcomes.

Glossary

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

artificially intelligent robot (AI robot): a robot that is able to use sensors to collect information and make autonomous decisions about how to complete a task even in a changing environment.

autonomy: the capacity to act independently or without external control.

bot: an AI agent that can interact with computer systems or users.

chatbot: a software program that simulates conversation with a human.

classification algorithms: a method of categorizing data into classes based on common features.

conversational agent: an AI software agent designed to have a natural dialogue with a user.

deepfake: a video created with artificial intelligence software that looks authentic but actually manipulates the face and/or voice of a person.

disinformation: incorrect information intentionally shared to mislead.

ethical: morally right.

extract: identify or separate out.

feature: unique measurable property.

generative adversarial network (GAN): a machine learning framework in which two neural networks are set against each other in order to produce new content.

machine learning (ML): a subset of AI involving the study of algorithms and models that machines use to perform a task without explicit instructions.

misinformation: incorrect information that is shared in the belief that it is true.

natural language processing (NLP): the AI technology used to understand and interact with human language.

robot: a machine that is able to perform complex tasks automatically.

sensor: a device that allows a machine to perceive the natural world.

training data: examples used to teach a machine learning model.

virtual assistant: an AI software agent that performs specific tasks based on a user's commands or questions.

APPENDIX A

Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and Baymax from "Big Hero 6."

Learn More

Video: "**What is AI (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**." This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students**"

Video: "**Algorithmic Bias and Fairness #18**"

Article: "**Ethical Concerns of AI**"

Article: "**Top 9 ethical issues in Artificial Intelligence**"

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

APPENDIX B

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Standards for Students																
Empowered Learner	x	x					x			x	x	x	x		x	x
Digital Citizen					x			x			x			x		
Knowledge Constructor	x		x	x		x	x	x			x		x			
Innovative Designer		x	x				x		x	x					x	x
Computational Thinker			x	x	x		x		x		x		x	x	x	x
Creative Communicator					x	x		x			x			x		
Global Collaborator							x					x	x			

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Computational Thinking Competencies																
Computational Thinking (Learner)				x	x	x	x		x	x	x	x	x		x	x
Equity Leader (Leader)					x	x	x	x							x	x
Collaborating Around Computing (Collaborator)	x			x			x					x	x			
Creativity and Design (Designer)	x	x	x	x				x	x	x	x			x	x	
Integrating Computational Thinking (Facilitator)		x	x				x		x	x				x		

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AI4K12 Five Big Ideas in AI																
Perception	x	x			x					x		x			x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x	
Learning	x			x		x	x				x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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Hands-On AI Projects for the Classroom

A Guide for Elementary Teachers

ISTE

GENERAL MOTORS

Hands-On AI Projects for the Classroom

A Guide for Elementary Teachers

About ISTE

The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

Related Resources

Teaching AI: Exploring New Frontiers for Learning by Michelle Zimmerman

ISTE online course, ***Artificial Intelligence and Their Practical Use in Schools***

To see all books available from ISTE, please visit **iste.org/books**

To see all courses available from ISTE, please visit **iste.org/isteu**

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Contents

Foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem-solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, artificial Intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large data sets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in **Appendix A: Unpacking Artificial Intelligence**.

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from jmc.stanford.edu/articles/whatisai/whatisai.pdf

Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority of them are focused on two general areas: automating administrative tasks, such as taking attendance and grading assignments, or increasing student performance through AI-supported assessment, personalized learning, and increasing engagement in typically mundane rote learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of this guide is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users and even creators of these powerful tools.

This guide is for educators who teach grades K–5. Why devote a guide to elementary education? Once the stuff of science fiction, AI now permeates nearly every facet of our lives. Many children are aware of tools like voice-activated assistants or navigators, but we may not recognize the importance of helping even our youngest students begin to understand that they are interacting with AI-supported tools and devices, and how these AI agents work. For example, we can help students realize that:

- AI does some things very well, such as image/speech recognition, but other tasks like discerning emotions or making ethical decisions are currently done better by humans.
- AI robots are able to interact with the environment around them because they have sensors that mimic animal senses.
- AI navigation systems are trained to analyze different ways to get from one place to another and make independent decisions regarding the shortest or fastest route to a destination.
- There are basic best practices for data collection for machine learning, including how data are gathered, classified, and organized using rules.

The beauty of AI-supported tools and devices is that they blend often seamlessly into our lives; we can employ them without having to give much thought about how they work. This is obvious to adults who grew up in a pre-AI world, but AI may appear to be mysterious or magical to children. They need to be explicitly taught that AI agents can be trained to imitate human intelligence, but they are not human. Awareness at this level does not require specific technical expertise. Educators with little or no prior experience with AI may still help their students become more informed about AI technologies. They can help by identifying instances of AI use, exploring the ethics of machines influencing the decisions we make, and understanding AI concepts enough that they can remind students that AI is a tool created by humans.

Until recently, conventional wisdom has suggested that K–5 students are too young to learn about AI due to the technical content. In reality, students in these grade levels have been taught skills that lead to an early understanding of how AI works: pattern recognition, sequencing, categorization, sorting, navigation skills, map reading, and even knowledge of animal senses are just a few of the competencies educators can leverage to help youngsters understand how AI works. The projects in this guide offer educators insights into ways they can frame these skills to help their students better understand AI.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach

The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their understanding of how AI technologies work, and create various authentic products—from presentations to designing an AI robot—to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the standards, concepts, and depth that would be appropriate to for students in grades K–5. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education, exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, the Training Data and Machine Learning project can be completed by students in any K–5 grade level; however, instruction regarding datasets and classification should deepen for older students. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI (shown in Figure 1).

The Five Big Ideas in AI serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution,

THE FIVE BIG IDEAS IN AI

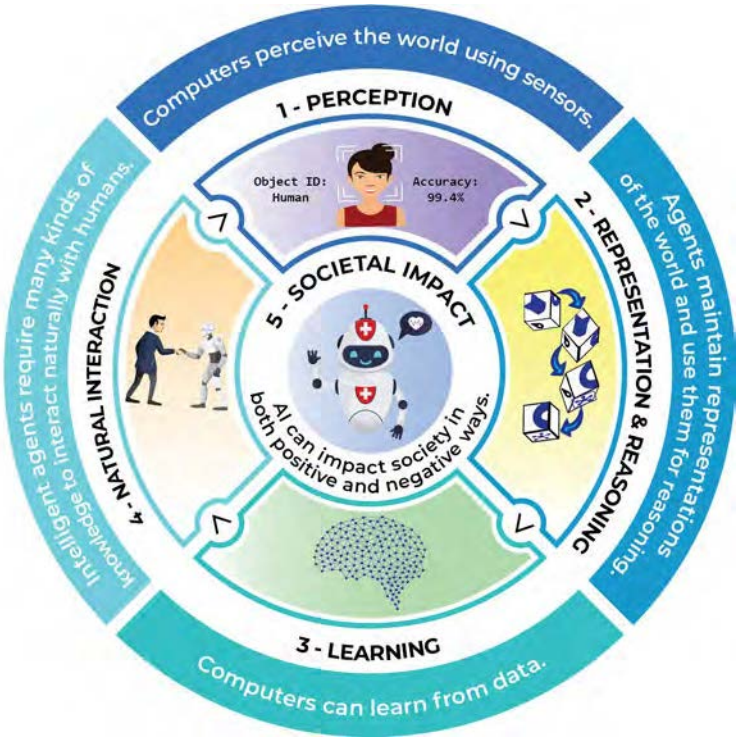

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities, or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both online and offline that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendices. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the Hands-On AI Projects for the Classroom series
- A discussion entitled "What Is AI?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows.

Project Overview

The project overview offers an explanation of what the project is, how it ties to research-based standards, and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject, target grades, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, ISTE Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

Preparation provides the information educators need in order to put the project into action with students. This section includes a list of materials required for project completion; a list of supporting resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools, reviewing online resources, etc.

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.
- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject area content.
- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE. ISTE does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Glossary and Appendices

Glossary

The glossary includes definitions for terms found in the projects that may be unfamiliar or need explanation for students.

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in all four guides in the *Hands-On AI Projects for the Classroom* series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1

What AI Does Well and Does Not Do as Well

When interacting with AI, elementary students often learn more about what AI cannot do well than what it can do well.

Project Overview

This project offers students opportunities to explore tasks AI is able to do well, such as image/speech recognition, and tasks done better by humans, such as discerning emotions or making ethical decisions.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

4–5 hours

TARGET GRADES

K–5

VOCABULARY

artificial intelligence
extraction
feature
image recognition

OBJECTIVES

At the end of this project, students will be able to:

- Identify types of tasks AI does well and explain how they know this.
- Identify types of tasks AI does not do well and explain how they know this.
- Understand that an AI is a computer program.

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

3. **Knowledge Constructor**
   - d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

ISTE Computational Thinking Competencies

3. **Collaborating Around Computing**
   - a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.

4. **Creativity & Design**
   - c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.

3. **Learning**
   Computers can learn from data.

4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Content Area Standard(s)

This project has been designed for implementation in any content area. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other modern advances in that field.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- 10 images—5 dogs and a mix of 5 other animals (e.g., cows, ducks, elephants, etc.), for each group of 3–4 students.
- Activity: **Aaron Wong AI Tic-Tac-Toe**
- Activity: **Bird Sounds**
- Activity: **Akinator** and **Mystery Animal**
- Tool: **Write with Transformer**

SUPPORTING RESOURCES FOR EDUCATORS

- Activity: **Intelligent Piece of Paper**

ADVANCED PREPARATION

- Familiarize yourself with each of the online resources.
- If you are working with children in grades K–2, watch the video "**What's intelligent about artificial intelligence**." Make note of the following two points: 1. One day, AI developers hope to create machines that can perform any task a human can. This is called general AI. 2. For right now, AI are limited to performing just one or a few limited tasks. This is called narrow AI. You will be mentioning these points to your students during the Activity 1 Discussion.
- Prepare 10 images for each group of 3–4 students. (5 images of dogs and a mix of images of 5 other animals, e.g., cows, ducks, elephants.) Number the images 1 to 10. Each group may be given the same sets of images. **Creative Commons Search** and **Pics4Learning** are sources of images.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students engage with the topic of what kinds of tasks AI can do well and what tasks it cannot do as well.

1. Ask students: What do you already know about AI around you? Do your parents use smartphones to navigate from one place to another? Do they have a voice-activated assistant in their home like Alexa or Google Assistant? Does someone in your family use Pandora or Spotify to select the music they listen to? Do they have a Netflix account that recommends movies to watch? How well do you think these computer programs and apps imitate human behavior?
2. Tell students that each of these is an example of **AI**. AI is the science and engineering of creating computer programs that can imitate human intelligence. AI cannot become human, but it can perform tasks in a human-like way.
3. If you are working with children in grades 3–5, show the video "**What's intelligent about artificial intelligence**." Discuss the video with students. Ensure that the following ideas are included in the discussion:
   - One day, AI developers hope to create machines that can perform any task a human can. This is called general AI.
   - For right now, AI is limited to performing just one or a few limited tasks. This is called narrow AI.
4. Brainstorm a list of AI technologies familiar to students. Include the name of the AI (e.g., Waze app or self-driving car) and the human behavior the AI mimics (e.g., navigating from Point A to Point B or driving a car). Tell students that in this project they will have opportunities to take part in offline and online activities that will help them learn more about some tasks AI does well, others that AI does not do well, and how AI learns to complete tasks.

TAKE A CLOSER LOOK

Activity 2: Two Tasks AI Does Well and Two Tasks AI Does Not Do As Well

In this online activity, students will share a laptop or tablet with a partner to explore four online examples of AI in action. If you are working with students in grades K–2, you may want to do some—or all—of these activities as a whole class.

1. Ask who plays Tic-Tac-Toe, who they like to play with, and who normally wins. Tell students that Aaron Wong has programmed an AI to play **Tic-Tac-Toe** using five rules for the AI to follow. Give students an opportunity to each play several games against the AI and request that they track how many times the AI wins, how many times they win, and how many times the game ends in a tie. Ask if playing Tic-Tac-Toe is a task the AI did well. Explain to students that this is an example of an AI trained to do one specific task. Point out that usually an AI can do one specific task very well. (See Extension Activity 1 for a related unplugged task.)

2. Ask students how birds communicate with one another. If they don't know the answer, explain that birds use calls to sound alarms or contact one another when looking for food, among other reasons. Tell them that it's possible to learn a lot about birds by listening to these calls and knowing what different bird calls sound like. To help people study birds, a group of programmers collected thousands of bird call recordings and put them into one large set called **Bird Sounds**. Then they created an AI that taught itself how to classify all the bird calls, find photos of the different birds, and label each of them. Now anyone can use Bird Sounds to find calls for specific birds, or just to explore. Give students several minutes to delve into the collection. Ask students if the AI did its task well. Was the collection easy to navigate? Were they able to browse the collection to access information about different birds? Were they able to find specific birds? Can they think of any ways to make the collection easier to use? Explain that this example and the Tic-Tac-Toe game are similar because they each do one thing. However, they are different because the Tic-Tac-Toe AI was trained using five rules, but with Bird Sounds, the AI taught itself how to identify, classify, and label the sounds. Say that the Bird Sounds AI is good at classifying and organizing sounds.

3. Tell students they are now going to play two animal guessing games that are AIs. The first is called **Akinator**. The class will think of an animal, and Akinator will try to guess what it is. The second is called **Mystery Animal**. In this activity students are challenged to guess an animal in 20 questions.

   - Begin with Akinator. Identify an animal for the AI to guess. Play the game as a whole class. How many questions did Akinator ask before guessing the animal? Was the guess correct? Were the questions clearly stated and easy to answer? Did you notice any patterns in the way questions were asked? Could these questions be helpful to you in the next game, where you need to ask questions?
   - Now give student pairs a few minutes to play the Mystery Animal game. Ask the following: What happened when you asked a question? Do you know how the AI "heard" you? Did the AI understand you right away when you spoke to it, or did you need to change the way you spoke to be understood by the AI? How many questions did you need to ask to correctly identify the animal? How is this game similar to Akinator, and how is it different? Do these two games work equally well, or does one work better than the other? Explain your answer. Help students understand that usually a text-based AI works better than a voice-recognition AI.

4. Finally, lead a class demonstration of **Write with Transformer**, a web app that is a demonstration site. It features two examples of AI text generators built using a text generation system called GPT-2 (checkpoints) and three models of different AI text generation systems. When you choose one of the five checkpoint or model options, you then type in a phrase or sentence, and the AI will generate three suggestions for the next phrase or sentence. You can briefly demonstrate just one option so students see how it works, or you can demonstrate multiple options to allow students to compare how each responds to the same initial prompt.

   - For example, click "Start Writing" for the first checkpoint. Click and drag to highlight the existing text, and type "I love to watch birds fly." Click "Trigger Autocomplete." This generates three responses. Read them aloud, ask students to choose the response that makes the most sense, and click on it. If none of the responses make sense, press the Tab key on your keyboard to generate three new responses. Repeat this process to generate additional responses, choosing those that make the most sense, if possible. The point is to give students the opportunity to see that much of what is produced is nonsensical.

- Ask students what could be done to make the text that's generated make sense. Help them conclude that a human being could edit the responses to make sense. Do this as a class. Ask the students if the Write with Transformer AI writes good stories. Ask them if they have any idea why this AI does not do this job well.
- You may repeat the above steps with the remaining checkpoint and/or with one or more of the models. Use the same initial sentence. Ask students to compare results of the different checkpoints and models. Are some better at generating responses that make sense with the initial prompt than others?

5. Ask students which of the four tasks were done well by the AI and which tasks were not. Tell students they are going to try two unplugged activities that will help them understand how an AI learns a task and why its capability might be limited.

Activity 3: Unplugged Activity–AI and Image Recognition

In this unplugged activity students learn how an AI uses images and physical characteristics to organize images of animals by type. If you are working with students in grades K–2, you may need to do the unplugged activities as a whole class.

1. Students work in small groups of 3–4 to complete this activity. Give each group 10 images, 5 dogs and a mix of 5 other animals (e.g., cows, ducks, elephants, etc.), and give each team one piece of writing paper. Tell students that they will be learning how an AI can be taught **image recognition** and how to organize images by type.
2. Ask one student on each team to turn the paper to landscape position and number it across the top from 1 to 10. Down the left side of each paper ask the student to list these five questions: Fur? Four legs? Paws? Tail? Mouth?
3. Explain that an AI can compare two images to see if they are identical, but that it is more complicated for an AI to recognize when two images might be of the same kind of thing when they are not identical. One way to teach an AI to recognize two images that are similar, but not identical, is to identify features of the image that can be used to tell one image from another. This is called **feature extraction**. An AI may not be able to "see" that two images are similar when they are not identical, but it can compare features. Give teams a few minutes to answer the questions for each image they have. Their answers should be "Yes" or "No."
4. Now tell students they will train the AI to recognize dogs. Say that to be a dog, the answer to each question must be "Yes." Have each team classify its images by dog or not dog, then check to see if the classification is correct. If students report that the classification is right, ask them which features eliminated images that were not dogs. If the classification is not accurate, ask them which image(s) ended up in the wrong group. During this discussion, ensure that students understand that the AI does not understand what it has been asked to do. It has simply followed the rule it was given—to place every image where the answer to all five questions is "Yes" into one group. It is especially helpful to have an AI do a task like this when dealing with a large amount of data, like the Bird Sounds collection explored in Activity 3.

CULMINATING PERFORMANCES

> **NOTE:** K–2 should work as a whole class; grades 3–5 as small groups.

Activity 4: Teach Something You've Learned

1. Ask students to think about all the different activities they have done in this project. Which did they like best and why? What did they learn about AI by doing that activity? Which activity was most difficult for them and why? What did they learn about AI by completing that activity? If they could choose one activity to teach to someone else, which one would it be and why?
2. Students in grades K–2 should work together to plan a presentation to share with another class. Students in grades 3–5 should work together to create learning stations where they can give their presentations during an event like an open house. The presentation or learning station should include:
   - An overview of what the students have been learning related to what AI does and does not do well.
   - A demonstration of the online or unplugged activity they decided to share.
   - An explanation of why the students chose that particular activity to demonstrate and what it taught them about what AI does or does not do well.

Activity 5: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of using AI.

- What did you learn about things AI can do well and not so well?
- Is AI the right solution for every problem? Why or why not?

Extensions

Here are two ways to expand students' exploration of what AI does and doesn't do well:

1. How the Tic-Tac-Toe game works: Students who played Tic-Tac-Toe against the AI may be interested in knowing why the AI almost always wins. Winning—or at least tying—every game of Tic-Tac-Toe is guaranteed when the player who goes first places the X in a corner and then faithfully follows four simple rules. They are:
   - Place the second X in the opposite corner. If an O was placed there, add the X to either of the other corners.
   - If there are two Xs and a space in a line, add the third X in that space. If there are two Os and a space in a line, add the third X in that space. If neither of those are true, add the third X to a free corner.
   - If there are two Xs and a space in a line, add the third X in that space. If there are two Os and a space in a line, add the fourth X in that space. If neither of those are true, add the third X to a free corner.
   - Add the final X to the free space.

Allow students to try playing using these rules. What happens when the first player follows the rules? What happens when the rules are not followed? Explain that the AI that plays Tic-Tac-Toe works because it uses an expert system that follows a set of rules once they have been learned.

2. The AI Tic-Tac-Toe game rules work well as long as the AI gets to go first, but what happens when it goes second? Pair students up to play several rounds of Tic-Tac-Toe. Student A gets to go first and can use any strategy they want. Student B goes second, but still must follow the rules listed in the first extension activity. What happens? Which person wins the most games? Why? The difference between a human and the AI that plays Tic-Tac-Toe is that a human is adaptable. Given new circumstances, a human will change the strategies used to solve a problem—winning at Tic-Tac-Toe in this case. This AI has been trained to solve a problem in just one way. The solution only works for the problem it was designed for—in this case, being the first player in a game of Tic-Tac-Toe. To be as intelligent as humans, an AI must be able to adapt.

PROJECT 2

Training Data and Machine Learning

A **machine learning algorithm** is a process or set of rules used by a computer to find and apply patterns in data. For this approach to succeed, tremendous amounts of accurate, relevant data are required. This **training data** must usually be supplied by people, but is sometimes acquired by the machine itself.

> This AI project is for regular classroom teachers, not just technology specialists. I think that is an essential point since teachers at any grade level might find the topic exciting but intimidating. The project is hands-on and utilizes manipulatives, which is crucial for concrete learners in the elementary grades.
>
> — Patricia Aigner, Technology Director & Fifth Grade Technology Teacher, Rutland City Public Schools

Overview

In this activity, students are exposed to basic best practices for data collection for machine learning, including quality and quantity, by participating in introductory, unplugged activities designed to demonstrate how data are sorted and organized using rules.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

2.5–3 hours

TARGET GRADES

K–5

VOCABULARY

algorithm
bias
data
database
dataset
digits
feature
machine learning algorithm
training data

PROJECT 2
Training Data and Machine Learning

OBJECTIVES

At the end of this project, students will be able to:

- Gather and organize a dataset.
- Check a dataset for bias.
- Create rules for organizing the data.

STANDARDS

ISTE Standards for Students

3. Knowledge Constructor

b. Students evaluate the accuracy, perspective, credibility, and relevance of information, media, data, or other resources.

5. Computational Thinker

b. Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

ISTE Computational Thinking Competencies

1. Computational Thinking Learner

b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.

3. Collaborating Around Computing

a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.

4. Creativity & Design

a. Design CT activities where data can be obtained, analyzed and represented to support problem-solving and learning in other content areas.

AI4K12 Five Big Ideas in AI

2. Representation and Reasoning

Agents maintain representations of the world and use them for reasoning.

3. Learning

Computers can learn from data.

5. Societal Impact

AI applications can impact society in both positive and negative ways.

Common Core State Standards for Mathematical Practice

CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP3: Construct viable arguments and critique the reasoning of others.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online.
- To complete this activity, you need a total of 85 vocabulary picture cards: 75 cards that fall within one general category (e.g., transportation, furniture, animals, food) and 10 vocabulary picture cards of items that do not belong in that general category. Suggestions for obtaining these cards are listed below in Advanced Preparation. The numbers of cards used in Activities 2, 3, and 4 vary as indicated below:

  Activity 2. General category—45 cards; not in the general category—5 cards.

  Activity 3. All cards used in Activity 2, plus an additional 20 cards in the general category.

  Activity 4. All cards used in Activities 2 and 3, plus an additional 10 cards in the general category and 5 additional cards not in the general category.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Statistics in the Elementary Grades: Exploring Distributions of Data**"

ADVANCED PREPARATION

Gather the cards required to complete Activities 2 through 4. Many elementary classrooms already have these. They may also be purchased online or at school supply stores, or you can make them yourself using images available on royalty-free sites such as **Pics4Learning**, **Pixabay.com**, and **Smithsonian Open Access**.

Instructions

GETTING STARTED

Activity 1: Algorithms and Data—an Introduction

In this activity, students are introduced to basic concepts related to algorithms and data.

> **NOTE:** This activity is appropriate for grades 3–5 and is optional for students in grades K–2.

1. Students may have heard terms like algorithm or data, but they may not actually understand what they mean. Begin this activity by helping students understand the following terms (You may need to reword the definitions provided here, depending on your students' skill levels):
   - **Algorithm.** A process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.
   - **Data.** The information computers store and send. Data takes many forms including video, pictures, text, and numbers.
   - **Database.** This is where data are stored. Data are often shown in a table, with rows and columns.
   - **Digits.** Numbers 0 to 9.
2. Watch the first 5:05 minutes of the video "**Episode 4: Data and Algorithms**." You may want to stop the video as points related to the vocabulary are made and discuss the information with your students. Stop the video at 5:05 minutes.
3. Ask students the following questions about the **dataset** in the sorting activity shown right before the video was stopped:
   - What did each item in the dataset have in common? (Pieces of candy in the shape of circles.)
   - How were the pieces of candy sorted? (From smallest to largest.)
   - Explain that datasets are organized by **features** or patterns. The dataset in the video represented pieces of candy in the shape of circles. Would a candy cane belong to that dataset? Why or why not? What about an M&M? Why or why not? What about a cake donut? Why or why not?
   - The data in the set of candy in the shape of circles was sorted by size: smallest circle to largest circle. That was the algorithm used to solve the problem of how to sort the data. If there were another piece of candy in the shape of a circle that was even larger than the pieces shown in the video, where would it belong in the series?
4. Explain to students that in this project they will explore how an AI is trained to organize data to complete a simple task by figuring out ways to organize the data, making sure there is a wide range of (unbiased) data within the set, and creating rules for organizing the dataset.

TAKE A CLOSER LOOK

Activity 2: What's a Dataset, and Getting Organized

In this unplugged activity, students will be given an overview of datasets: what they are and how they might be organized by labels.

1. Demonstrate Google's AI Experiment **Quick, Draw!**. You may want to show students the video on the Quick, Draw! site beginning at 0:52, or just play the game, whichever is best for your students. Tell students that training an AI to complete a task like recognizing an object that's drawn by someone requires a lot of data. In this unplugged activity, they will get a sense of how a dataset is used to teach an AI to recognize and classify things.
2. Place the first 50 vocabulary picture cards (45 in the general category and five not in the category) on a large table or on the floor so the class can see them. Ask students to look at the images and think about what overall category most of the pictures seem to represent. For example, cards showing things like bicycles, cars, boats, and trucks could represent the dataset *kinds of transportation*. Have students decide on the overall category and explain their thinking. If students notice the 5 cards that do not fit the general category, set them to one side, but leave them next to the other cards, because they are still part of the dataset for now.
3. Explain to students that 50 cards can be hard to work with all together, but would be easier to use if grouped into smaller categories. Have students imagine how hard it would be to work with a dataset of hundreds or thousands of images—like an AI does—without some way to organize them. Ask them to look at the cards again and think of ways the cards could be classified into smaller groups by assigning a label to each card. In this example, you might suggest they could use labels like things that travel on *land*, on the *sea*, or *in the air*. Classify the cards using these labels. Ask students: Is it easier to get a good idea of what kinds of cards are in the dataset when the cards are organized this way, instead of in one large group? If students ask about the 5 cards that do not belong in any of the smaller groups, say they will be taken care of in Activity 3. Now that students have identified labels for the cards in the dataset, explain that in the next activity, they are going to check the dataset to be sure that there are several examples of each type of transportation, and to be sure that every card in the dataset belongs there.
4. Hold a class discussion. Ask students to review the steps they took to name the entire dataset and then to identify labels. Challenge them to name other labels they might have used. In this example, they might have used *things that have wheels* and *things that do not have wheels*. Or, they might have labeled the cards *kinds of public transportation* and *kinds of private transportation*. There are many possibilities!
5. If you plan to go right on to Activity 3, leave the cards as currently classified and proceed to step 2 of the next activity.

Activity 3: Checking the Data

In this part of the unplugged activity, students are given an overview of why it's important to check the data in a set before using it to teach an AI.

1. This activity uses the same 50 vocabulary picture cards from Activity 2, as well as 20 additional cards that belong in the general category (set these aside initially). If you completed Activity 2 previously and have since picked up the picture cards, have students classify them again, using the labels they identified in Activity 2.
2. Ask students to look at the entire dataset, which they have grouped by labels. Ask them to look at one of these groups. In the example we've been working with, that could be *things that travel on land*. Ask students to brainstorm all the kinds of transportation that travels on land, such as bicycles, motorcycles, cars, trucks, busses, trains, tricycles, etc. Are there types of transportation they've named that are not included in the pictures already in that group? If so, ask them if it is important to include one or more examples of that type of land transportation in the dataset, and to explain their reasons. Say that whenever datasets are created, it's possible that important information might be left out. When this happens, the data are considered **biased**. That means that the dataset is not a good example of a category, because it is missing important information. To improve the dataset, the missing data need to be added. If students decide that the missing data are needed to fairly represent types of land transportation, ask them to look at the additional 20 cards they have not yet seen to find examples that can be added to the group. If the missing pictures are not available in the extra cards, search for them online, or draw them and add them to the group. This is the process of checking the dataset to be sure that it is diverse. Repeat these steps for the other labeled groups (*kinds of transportation that travel on water and in the air*, for this example). Add additional pictures as needed.
3. The next step is to remove cards that don't belong in the dataset. Note that this is another way data can be biased: by including information that does not belong in the dataset. Direct students' attention to the 5 pictures that do not represent kinds of transportation. Say that it's important for the information in a dataset to be accurate, because the data are going to be used to train an AI to recognize different kinds of transportation. Mention that an AI cannot think for itself, so it will not automatically recognize incorrect data. Help students come to the conclusion that these cards should be removed from the dataset.
4. If you plan to go right on to Activity 4, leave the cards as currently classified and proceed to step 2 of the next activity.

Activity 4: Creating Rules to Organize Data

In this part of the unplugged activity, students create rules for classifying any new cards added to the dataset.

1. This activity uses the same 70 vocabulary picture cards that were included in the dataset at the end of Activity 3. If you completed Activity 3 previously and have since picked up the picture cards, have students classify them again, using the labels they identified in Activity 2.

2. Tell students that it is possible to teach an AI how to determine if new data should be added to the dataset and to organize that new data. To do this, the programmer needs to develop rules about why a piece of data belongs to a particular category. Ask students how they knew which cards belonged to each of the labels they created in Activity 2. Help them conclude that they looked at each card and used knowledge they already had about the content to identify the features and patterns that differentiate pieces of data from one another.
3. Ask students to choose one of the labels created during Activity 2 and brainstorm a list of the features and patterns that can be used to identify cards that belong in that label. Using the example we've been working with, the label could be *land transportation*. What were some of the features students used to identify forms of transportation that belonged in that label? Students may suggest things like:
    - Has wheels
    - Is steered
    - Is piloted by someone/something
4. Test this rules list using existing data to be sure that the rules work. For example, "has wheels" is a sample rule. Look at the other labels. Are there forms of transportation there that have wheels? You probably have pictures of airplanes. Airplanes do have wheels, but they are used only for taking off and landing. Most forms of land transportation use wheels as their primary method of travel. How could the list of rules be modified to account for both situations? Try adding a rule: cannot fly. Would that eliminate forms of air transportation that may have wheels, but travel primarily in the air?
5. Are there cards that were included in *land travel* but do not fit in that label now because they do not have wheels, are not steered, or aren't piloted by someone/something? If a picture of a sleigh or sled is in the dataset, having no wheels would eliminate it from the label, but would that be correct? Perhaps "has wheels" is not an accurate rule for land vehicles after all. Could the rule be amended to include vehicles that are wheeled, tracked, railed, or skied? That would include sleighs and sleds in the land vehicle group, where they belong. The new rules might be vehicles that:
    - Are wheeled, tracked, railed, or skied
    - Cannot fly
    - Are steered
    - Are piloted by someone/something
6. Do all the cards currently in the group still belong there using these rules?
7. Now ask students to look at the additional 15 vocabulary picture cards (see the Materials list) you've gathered for this activity. Which of these new cards belong to this label, based on the rules? Why? Add those cards to the *land transportation* label.

CULMINATING PERFORMANCES

Activity 5: Organize the Remaining Data

In this final part of the unplugged activity, students will finish organizing the dataset by creating and testing rules for the remaining labels in the dataset.

1. **Grades K–2:** As a whole class, repeat the process described in Activity 4 to develop rules for the additional labels that students identified in Activity 2. Have students create and test rules for each label, then look at the 15 new cards to see which belong to the remaining labels, and which do not belong in the dataset (there should be 5 that do not belong to any label and therefore do not belong in the dataset).
2. **Grades 3–5:** Allow students to form groups of 3–4. Allow each group to repeat the process described in Activity 4 to develop rules for the additional labels that students identified in Activity 2. Have students create and test rules for each label, then look at the 15 new cards to see which belong to the remaining labels, and which do not belong in the dataset (there should be 5 that do not belong to any label and therefore do not belong in the dataset).

   Then, discuss the following as a class:

   - What did you learn about datasets and how they can be organized?
   - Describe some of the ways you thought of to create labels for the dataset you worked with.
   - What was most challenging about creating rules for adding items to labels?

Activity 6: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of creating and using datasets to train AI.

- How would an AI like Quick, Draw! be changed over time if people intentionally drew pictures incorrectly?
- How would an AI trained with the card data in our activities be affected if the rules were wrong?
- Why is correctly training AIs important? How could incorrectly trained AIs change our lives?

Extensions

Here are four ways to expand students' exploration of training data and AI:

1. Students in grades K–2 can practice the skills they've used during these activities by working in a learning center where they form datasets using manipulatives like pattern blocks, Cuisenaire rods, playing cards, colored counters, math link cubes, etc., to create datasets, identify labels within the dataset, check the quality of the dataset, and then develop rules for adding new items to the labels.
2. Students may have used Google Image Search to find photos to use in schoolwork. Ask if they have ever wondered how Image Search is able to identify images using keywords. Explain that the Image Search dataset is a much larger version of the image dataset they worked with during this project. Give them time to explore Microsoft's **COCO: Common Objects in Context** collection of images, which is organized by an AI. This dataset contains 91 common object categories (labels) and includes 328,000 images (dataset). Students may search for images that fit into one or more of the object categories.
3. Students in grades 3–5 can be challenged to work in teams to create their own datasets, which they will label, check for accuracy, and organize using rules they develop. Students may present their work to the whole class.
4. Classification algorithms are just one way an AI organizes data. Another way is through sorting algorithms. Students in grades 3–5 can explore various sorting strategies by viewing brief videos and then replicating the strategies shown using math manipulatives like: pattern blocks, Cuisenaire rods, colored counters, math link cubes, or LEGO. Following are links to the videos:
   - "**LEGO Bubble Sort**"
   - "**What's the fastest way to alphabetize your bookshelf?**"
   - "**Simple exchange sort**"

PROJECT 3

Senses vs. Sensors

Project Overview

In this project, students will identify the senses that animals, including people, use every day. They will explore the ways animals use their senses, and learn that robotic devices have sensors that mimic animal senses, enabling robots to interact with the environment.

SUBJECT

Science and Health

ESTIMATED DURATION

4 hours

TARGET GRADES

K–5

VOCABULARY

artificial intelligence
artificially intelligent robot
autonomous
image recognition
natural language processing
robot
sense
sensor

OBJECTIVES

At the end of this project, students will be able to:

- Explain how animals, including humans, use their senses to interact with their environment.
- Describe some ways AI robot sensors mimic animal senses.

STANDARDS

ISTE Standards for Students

1. **Empowered Learner**
   - c. Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
4. **Innovative Designer**
   - a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

ISTE Computational Thinking Competencies

4. **Creativity & Design**
   b. Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.

5. **Integrating Computational Thinking**
   b. Empower students to select personally meaningful computational projects.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Next Generation Science Standards

NGSS: K-LS1-1: Use observations to describe patterns of what plants and animals (including humans) need to survive.

NGSS: 4-LS1-2: Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Writing/Drawing materials: Paper, chart paper, magnet boards, and/or sticky notes, and drawing supplies.
- *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots*by Jennifer Swanson,[2] or another book that explains the sensors used by robots in simple language.
- Building blocks for stacking into a tower.
- Tool: Google's **Semi-Conductor**
- Tool: **Speechnotes**
- Tool: **Magic Sketchpad**

2 Swanson, J. (2016). *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots*.

SUPPORTING RESOURCES FOR EDUCATORS

- Directions for **Harold the Robot** unplugged activity.
- Article: "**How Many Senses Does a Human Being Have?**"
- Article: "**Making 'Sense' of Robot Sensors**"
- Article: "**Types of Robot Sensors**"
- Article: "**What's the Difference between Robotics and Artificial Intelligence?**"

ADVANCED PREPARATION

- Find examples of robotic sensors to share with students, either in a book like *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots* by Jennifer Swanson, or online.
- Become familiar with common types of robotic sensors for perceiving light, proximity, sound, temperature, and acceleration.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will engage with the topic of AI robots perceiving the world using sensors.

1. Ask students: How do people and animals interact with the world around them? What do you need to do to cross a street safely, enjoy a song, or decide if you like a certain food? Guide students to conclude that people and animals use their **senses** to help them navigate their environment by making decisions about the actions they take. Help students list the five basic senses people use (sight, hearing, taste, touch, smell). Ask the following questions: What do you know about your senses? How do you use your senses to make decisions about actions you take? Does what you learn apply in future situations that are similar?
2. Ask students to brainstorm ideas about why **robots** might need to interact with their environment. Share a book like *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots* by Jennifer Swanson to show examples of robots that have sensors. Ask students the following questions: Have you seen or heard about robots that can vacuum a floor, wash windows, or clean the cat's litterbox? How do these robots do these tasks? Once the robot has completed the task correctly, do you think it can apply what it has learned in similar situations? Explain that some robots are able to use their sensors to collect information and make **autonomous** decisions about how to complete a task even in a changing environment. These are called **artificially intelligent robots**, or AI robots.
3. Explain to students that the activities in this project will help them learn more about senses and sensors.

TAKE A CLOSER LOOK

Activity 2: Experimenting With Sensors

In this activity, students will experiment with three types of sensors that AI robots can use to perceive the world.

Explain to students that some—but not all—robots have **sensors** that enable them to interact with their environment. Remind them that robots that are able to use sensors to collect information and make autonomous decisions about how to complete a task are called AI robots.

1. A camera is one type of sensor that an AI robot can use to see. Give students a chance to experiment with an AI-powered **image recognition** application like Google's **Semi-Conductor**, which uses a webcam to see a person's movements, then analyzes and maps out the position and movement of the person with a neural network, and finally responds by having an orchestra play accordingly. Discuss the map of the movement on the screen, and ask students what the **AI** is seeing.
2. A microphone is a type of sensor that an AI robot can use to hear. Have students experiment with an AI-powered sound or voice application, such as **Speechnotes**, which listens to the student speak, uses **natural language processing** for speech recognition, and displays what the user said in text on the screen. Discuss the output on the screen and ask students how accurate the AI was at hearing and understanding the user.
3. A trackpad or touchscreen are sensors that an AI robot can use to perceive touch. Prompt students to experiment with an AI-powered touch-sensitive application like **Magic Sketchpad**, which perceives touch through a trackpad or touchscreen, maps the touch using lines on the screen, and uses a neural network to predict the rest of the user's doodle. Have students try to draw what the AI is expecting as well as things it does not expect. Discuss the accuracy of the mapping as well as the AI's guess about what would happen next in the doodle.

Activity 3: Introduction to Robots and Sensors

This activity is a variation of the classic **Harold the Robot** unplugged activity.

1. Students give directions for completing a task to an adult who interacts with the environment based on the directions being given—in this case, building a block tower. When the directions are completed, ask students to identify how many and which of the five basic senses the robot needed to use to follow the directions.
2. An AI robot is able to complete tasks autonomously without being given step-by-step directions. If an AI robot could complete this activity on its own instead of being given step-by-step directions, what would it need to be able to do without help? This activity is intended to expose students to the idea that it is possible for an AI robot with sensors to learn how to complete a task without being given specific directions every time.

3. In a class discussion, brainstorm ideas for an AI robot that could be trained to complete a different task. What might the task be, and what sensors would the robot need to complete the task? Record students' ideas for the next activity.

CULMINATING PERFORMANCES

Activity 4: Design an AI Robot

In this unplugged activity, students will design an AI robot that has the sensors it would need to perform a specific task. Students in grades K–2 will complete this as a whole class project. Students in grades 3–5 may complete this project in small groups.

1. Remind students that an AI robot uses sensors to perceive its environment and then uses the information to autonomously complete a task.
2. Review the list students generated when they brainstormed ideas for tasks they would like a robot to be able to complete. Select one from the list to use as a model. For example, perhaps students said they would like a robot that could wash dishes. An AI robot could be a logical solution. What would the design for this robot need to include? Walk the class through your example using the following 4 steps:
   - Name the AI robot and state its purpose: Dishbot—This AI robot saves time at home and in other places where food is served by loading and operating dishwashers.
   - Where would you find this AI robot? In private and commercial kitchens.
   - How does the AI robot move? Cylinders and motors control its moving parts (e.g., robotic arms and hands); wheels allow it to travel.
   - Which sensors would this AI robot need? Touch sensors let it know when it touches/is holding something; a camera enables it to "see" objects; and a sensor tells the robot its location in the kitchen in relation to the dishes and dishwasher.
3. The next step in this project is age dependent.

   Grades K–2. Once the class has walked through the above four planning steps, ask them to work in pairs or trios to draw an AI robot based on the class description. Nonwriters may dictate descriptions of their robots to a class helper to be recorded. Writers may create a pair/trio description of their robot to explain how their robot interacts with its environment to complete the task identified by the class. Student pairs/trios present their completed work to the class, creating an AI robot gallery for display.

   Grades 3–5. Students work in small groups to identify a task they want an artificially intelligent robot to complete. Each small group develops a presentation for the class that includes:

- A four-step description of their AI robot, as above.
- A drawing or a written example of the AI robot in action.
- A written description of what the AI robot is and how it will complete the task identified.

Activity 5: Reflect

In this activity, students should discuss the following question to reflect on their learning and consider the societal impact of using AI robots.

- How could the AI robot you designed for this project affect your life or the lives of your friends and family? Is it a good idea to have AI robots do things instead of people? Why and why not?

Extensions

Following are two ways to expand students' exploration of robots, AI, and sensors:

1. As we work to achieve interactions with technology that are so natural they become nearly unnoticeable, it's important that we ensure that young children are able to recognize that in addition to similarities between humans and robots (with or without AI), there are differences.
   - One strategy for clarifying this separation is to refrain from anthropomorphizing these machines. Supporting resources: "**Does your kid know: Robots have no feelings**," "**PopBots: An early childhood AI curriculum**," "**The Danger of Anthropomorphizing AI**"
   - Hold a class discussion. Have students brainstorm a list of AI robots they are familiar with. For example, they may include iRobot, Roomba, Roxxter, RX-V100, or similar AI robots. Ask students what pronouns they use to refer to these machines and why. Have a discussion about why designers might want to make AI robots seem to be human-like. Include a discussion about the fact that these devices are not "magical."
2. Introduce students in grades 3–5 to two additional animal senses: position in space and balance. For more information, see **7senses.org**
   - Ask students: How do robots locate their position? Resource: "**How a robot finds its location based on what it 'sees'**" How do they keep their balance? Resource: "**Two-legged robot mimics human balance while running and jumping**"
3. Facilitate this unplugged activity: Ask students if they know how some animals can tell where they are when they are under water or at night. Explain that these animals are likely using something called *echolocation*. The animal makes a noise and then listens for the echoes, which help the animal locate nearby objects. Show the video "**What Is Echolocation?**" to help students understand how echolocation works and why it's important. Tell students they are going to mimic echolocation themselves using the following steps:
   - Give each student a piece of writing paper and ask them to number it 1 through 9.

- Next to each number they will write one of the following words in any order: front, back, side. Students should not show their paper to anyone else.
- Have students pair up. Ask pairs to spread out around the classroom.
- One student in the pair should close their eyes.
- The student whose eyes are open should stand near their partner and snap their fingers or clap in front of, behind, or beside the blindfolded partner, following what they wrote on their paper.
- The partner with closed eyes will guess the location of each snap/clap and the other student will record if the guess was correct or incorrect. Repeat for a total of 9 snaps/claps.
- Partners should switch roles and repeat the exercise.
- Students should total how many times their partner guessed correctly and incorrectly.
- Lead a class discussion about the experience. How does this exercise relate to learning about additional senses, robots, and AI?

PROJECT 4

Navigation and AI

Getting from one place to another using AI-supported navigation systems has become a way of life. While early automobile GPS systems seemed to be miraculous, by today's standards, those systems were expensive and quite limited in their abilities to adapt to changing road and traffic conditions. Today's navigation systems are apps on smartphones or tablets. They fuse GPS with other sensors and data to make on-the-fly updates to directions when road and traffic conditions change.

Project Overview

In this activity students will participate in unplugged activities to explore how AI-supported navigation works. As an extension, older students may use Minecraft to build a block-based maze and teach an agent how to navigate the maze on its own.

SUBJECT

English language arts, math, geography

ESTIMATED DURATION

5–6 hours

TARGET GRADES

K–5

VOCABULARY

artificial intelligence
symbolic representation

OBJECTIVES

At the end of this project, students will be able to:

- Explain that maps are representations of the world.
- Familiarize themselves with a school map and use that map to plan routes from one location on campus to another.
- Describe their understanding of training an AI in navigation.

STANDARDS

ISTE Standards for Students

3. Knowledge Constructor

- **d.** Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

4. Innovative Designer

- **a.** Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

5. Computational Thinker

- **d.** Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

ISTE Computational Thinking Competencies

4. Creativity & Design

- **b.** Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.
- **c.** Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

5. Integrating Computational Thinking

- **c.** Use a variety of instructional approaches to help students frame problems in ways that can be represented as computational steps or algorithms to be performed by a computer.

AI4K12 Five Big Ideas in AI

2. Representation and Reasoning

Agents maintain representations of the world and use them for reasoning.

5. Societal Impact

AI can impact society in both positive and negative ways.

Common Core State Standards

CCSS.ELA-LITERACY.W.K.7 – 5.7: Production and Distribution of Writing

CCSS.ELA-RL.K.3 – 5.3: Key Ideas and Details

Common Core State Standards for Mathematical Practice

CCSS.MATH-K – 4.OA.C.5: Generate and Analyze Patterns

Next Generation Science Standards

Concepts related to pattern recognition and data analysis are interwoven throughout these standards.

National Geography Standards

National Geography Standard 1

At all grade levels, students need practice and experiences in how to collect and display information (data) on maps, graphs, and diagrams. They must understand what a map is and what it can—and cannot—do. They need to be able to read and interpret maps and other geographic representations. And finally, students must know how to make maps, from hand-drawn sketch maps to more complex representations using a range of appropriate technologies.

Preparation

MATERIALS

- A printed road map.
- A list of directions to any location.
- A phone, tablet, or laptop with internet connection, and a method for projecting what's on the device's screen.
- A large piece of butcher paper (for classroom floor plan).
- Pencils and markers.
- Double-sided tape.
- Construction paper cutouts that represent unfixed items to place on the classroom floor plan (e.g., desks, tables, bookcases, easels).
- 5–6 items to hide in the classroom.
- Construction paper cutouts that represent the hidden items.
- School maps (one copy per student, labeled if used with grades K–2, blank if used with grades 3–5).
- Crayons or colored pencils (each student needs one red, one blue, and one green).
- Printed copies of the three difficulty levels of mazes (easy, medium, hard), one of each level per student.
- Activity: **Code.org Course 2, Lesson 3. Maze: Sequence**
- Tool: **Google Maps**, **Maps**, **Waze**, or another AI-powered maps app.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Deepmind teaches AI to follow navigational directions like humans**"
- Article: "**Claude Shannon**"
- Resource: **Krazydad mazes** and **All Kids Network Free Printable Mazes**
- Article: "**Teaching AI to navigate like our brains**"
- Article: "**Using artificial intelligence to enrich digital maps**"

ADVANCED PREPARATION

Collect all materials and organize them by activity.

An AI-powered maps app is often pre-installed on smartphones and tablets. Confirm access and review functionality if needed. Alternatively, bookmark the **Google Maps** website on a laptop. Ensure you can project the screen on whatever device you are using.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will engage with the topic of AI-supported navigation and how it works.

1. Ask students: How do the members of your family who drive know how to get from one place to another in the car? Does it make a difference when the person driving already knows how to go somewhere, and when the person doesn't know where the destination is? Guide students to conclude that when the driver wants to go to a familiar place, they know how to navigate there unassisted. However, when heading to a new location, the driver will need help in the form of a map, a set of directions, or a navigation app like Google Maps, Maps, or Waze. Ask students which kinds of help their family members use when going to an unfamiliar location.
2. Demonstrate how these three types of tools help humans navigate: a printed road map, written directions, and a maps app.
    - First, show students the road map. Ask if they know what it is. Explain that people used to rely on printed road maps whenever they drove to unfamiliar places.
    - Then show students the written directions and explain that this was another navigation method used in the past. Describe how people used written directions when driving.
    - Finally, demonstrate the AI-powered maps app you selected, preferably on a tablet or smartphone. Show students how to add a destination, how to choose a starting point, and how the suggested route is displayed. Explain to students that this type of navigation app uses **AI**—the science and engineering of creating computer programs that can imitate human intelligence—to analyze different ways to get from one place to another and pick the shortest or fastest route.

TAKE A CLOSER LOOK

Activity 2: Creating and Navigating Classroom Floor Plans

In this unplugged activity, students will have an opportunity to explore spatial skills and navigation concepts by creating a map (a floor plan) of a familiar space—the classroom—and then using that map to navigate the space. Students will transfer their learning from this experience to understanding how AI represents the world. (The activity is designed for students to create one whole-class floor plan, but students in grades 3–5 may want to create individual floor plans instead.)

1. Explain to students that in order for an AI to make independent decisions, it must first have a model—or **symbolic representation**—of the world. A map is one kind of model. If the AI is going to make a decision about the best directions from one place to another, it will need a map that includes roads, buildings, and other landmarks.
2. Tell students that they are going to create an example of a representation of the world (model) by making a detailed floor plan (map) of the classroom on a large piece of butcher paper.
3. Depending on students' ages, you may need to explain that floor plans can show both the fixed structures of the room (e.g., walls, doors, closets, and windows) and unfixed items placed in the room (e.g., desks, tables, easels, and bookcases).
    - Demonstrate how to draw the fixed structures of the floor plan, and show students how to use the construction paper cutouts to represent the unfixed items on the floor plan. Help students make a pencil sketch of the fixed structures of the classroom on the butcher paper. Allow them to refer to the cutouts for the unfixed items that will be placed on the floor plan to ensure that the floor plan is large enough to accommodate the unfixed items, without being too large. Once students are satisfied with the pencil sketch, have them use markers to make that part of the floor plan more visible. Then ask students to place the construction paper cutouts on the floor plan, taking care to replicate the actual placement of unfixed items in the classroom. When students agree that the placement is correct, use double-sided tape to affix the cut-outs to the floor plan.

> **OPTIONAL:** For older students, you may want to extend the activity to apply students' understanding of scale and estimation. Explain that sometimes a person drawing a floor plan will measure the room and the objects in it so that the floor plan accurately depicts fixed and unfixed features. The floor plan is said to be drawn "to scale" if it and the actual room are the exact same shape but different sizes. Students could measure the classroom and objects to draw their floor plan to scale. Let students know that while their classroom floor plan will have the same general shape as the actual room, they likely will not measure everything to draw it exactly to scale.

4. Now, play a game so students will better understand symbolic representation using the floor plan.
    - While the students are out of the room (for lunch or recess), hide 5–6 items you've selected (see the Materials list) around the classroom. Tape the construction paper cutouts of these items to the floor plan in the places where they've been hidden.
    - Gather students around the floor plan. Ask them to identify what's been added to it. Divide the class into teams of 3–4 students and challenge them to locate the hidden items using the floor plan as a map. (If older students have created individual floor plans, give them a list of the items that have been hidden in the room and ask them to mark each object on their floor plan when they locate it.)
5. Wrap up this activity with a discussion reminding students that floor plans are a type of map, that maps are a symbolic way to represent the real world, and that AI uses maps and other models to represent the world around them.

Activity 3: More Than One Way to Get Somewhere

In this unplugged activity, students will be reminded that maps are representations of the world that can be used for reasoning. They will also be exposed to the idea that it's possible to learn from data provided on the map. They will familiarize themselves with a school map and plan routes from one location on campus to another, based on criteria provided by the teacher. Plan a whole-class activity for students in grades K–2 or a small group/individual activity for students in grades 3–5.

1. If working with grades K–2, give each child a copy of a labeled school map. If working with grades 3–5, give each child a copy of a blank school map. Ask students to tell you what they see, and what they think the map represents. If necessary, help them identify it as a school map. With K–2 students, review features of the map, and help them identify important locations on campus such as the playground, the library/media center, the cafeteria, the office, and specific classrooms. With grade 3–5 students, review the features of the map, and ask them to label important locations including those listed above.
2. Have students bring their maps outside the classroom. Explain that although students are familiar with campus already, they can still use the map to figure out different routes to various locations. Ensure that students are aware of how to hold the map to orient themselves, and then tell them the class is going to walk the campus using the map. Ask students to look at the map to decide how to walk from your classroom to the cafeteria. Call on a volunteer to describe one route to the cafeteria, showing on the map how they would walk there. Call on another volunteer to describe a different route to the cafeteria, showing that route on the map. Ask if there are additional routes the class could take to get to the cafeteria. Have a volunteer show you a third route, and then have that student guide the class to the cafeteria using the map. You may repeat this activity once or twice more, asking students to identify various routes to several locations on campus.

3. Return to the classroom. Ask students if they always use the same route to go from one place on campus to another, and to explain why. Help students see that different routes might be chosen based on factors like time (which route is quickest), distance (which route is shortest), or ease of use (the physical condition of the walkway, the number of students taking the same route, avoiding stairs when walking with crutches). Have students brainstorm additional reasons for choosing a different route to go from one place to another. List their ideas.
4. Choose 3 ideas (e.g., flattest route, fastest route, prettiest route) and assign each route a number: 1, 2, or 3. Tell students they are going to identify 3 different routes between the classroom and another spot on campus (teacher's choice). Explain that the red crayon represents route 1, the blue crayon represents route 2, and the green crayon represents route 3. Students will need to go outdoors to plan and record their routes (this may be a whole-class exercise for grades K–2 and a small-group or individual exercise in grades 3–5).
5. Return to the classroom. Ask students to explain the process they used to plan each route. What criteria did they use to identify the routes?
6. Remind students of Activity 1, which included a demonstration of 3 ways people navigate from one place to another (print maps, written directions, and navigation apps) and a discussion of which of these tools their family members use. Point out that students used paper maps in Activities 2 and 3. Ask them to compare and contrast ways these activities might have been different had they needed to rely on written directions or a navigation app to complete each task. Responses may include statements such as writing step-by-step directions could be more difficult and time-consuming than drawing a route on a paper map, or entering a destination into a navigation app. Remind students of the initial discussion in step 5 of this activity. Say they have identified strategies they used to identify their walking routes, and those would also work for writing directions, but what about navigation apps? How do the AI agents that make these apps learn to navigate from one place to another? Tell students they will learn more about how AI navigates in the next two activities.

Activity 4: Teach an Angry Bird to Navigate a Maze

This activity challenges students to explore the thought process behind teaching an AI to navigate a simple maze.

Although this activity does not incorporate AI, it helps elementary students understand the thought process behind teaching an AI to navigate a simple maze. View the activity "**Code.org Course 2, Lesson 3. Maze: Sequence**." Allow students to work individually or in pairs to complete this activity.

1. Model for students how to access the website for the activity. Before asking them to go to the site, show the class the tutorial video that appears on the webpage when it opens initially. This explains the task and how to use Blockly to program a path through the maze.
2. Now have students navigate to the site and click the X in the upper-right corner of the tutorial video to bypass it. The directions will appear on the page. Read them, and click "OK" to begin. This activity offers 11 levels, ranging from easy to hard. Allow students to complete as many levels as they can.

3. Conclude this activity by having a debriefing discussion with students. Discuss their experiences in using Blockly to program the bird to navigate the maze to reach the pig. How does this relate to AI-supported navigation systems? Help students conclude that—although on a much more sophisticated level—the AI navigation systems work on the same underlying principles that the students used in this activity. Just as students had to learn how the map works and use reason to get through the maze, an AI-supported navigation system must be trained with the map and use reasoning to provide directions for moving from one location to another.

CULMINATING PERFORMANCES

Activity 5: Rule-Based Navigation of Mazes

This activity challenges students to apply the skills they have learned related to training an AI to navigate a simple maze. Given one training rule, students will attempt to complete mazes ranging from very easy to difficult using just that rule.

1. Tell students that in 1950, a man named Claude Shannon created an electronic mouse that was able to teach itself how to navigate physical mazes. While not as sophisticated as training an AI to navigate a maze, this is believed to be one of the world's first examples of machine learning. Today, training an AI to navigate a maze based on the use of one or more rules is a common activity. One approach is for the AI to wander the maze randomly until it finds its way through. Another approach is to train the AI using one or more rules such as the left-hand rule, which says to *follow the left-hand wall until you reach the exit.*
2. Print three paper mazes ranging from very easy to difficult (one copy of each per student). Printable mazes of varying levels of difficulty are available online; two sources are **Krazydad mazes** and **All Kids Network Free Printable Mazes**. Give each student three mazes ranging from simple to difficult and challenge them to solve all three using the left-hand rule.
3. Are students able to complete all the mazes, regardless of difficulty, by following that one simple rule? Ask students to share their experience, and to decide if just one rule is enough. Tell students that yes, if they follow that rule they will almost always be able to get through the maze eventually. It also works to follow the right-hand wall.
4. End the activity with step 3 for K–2 students. With students in grades 3–5, say that random wandering or the left-hand rule can be used to solve mazes, but that these strategies are not always the most efficient way to approach this problem—that there are other maze-solving strategies they can explore. For example, could they find a faster way to solve the mazes they were given, or perhaps find the shortest route to solve a maze? Using fresh copies of the same mazes, ask students to try solving the mazes using a different strategy, and then write down the rule(s) they used for each maze.

Activity 6: Reflect

In this activity, students should discuss the following question to reflect on their learning and consider the societal impact of using AI-supported navigation systems.

- How do AI-supported navigation systems affect your life or the lives of your friends and family? Is it a good idea to rely on these systems to navigate from one place to another? Why or why not?

Extensions

Here are three ways to expand students' exploration of AI and Navigation:

1. Students in grades K–2 can practice their skills at plotting the shortest route from the school gate to the school door by completing the online activity **Late Again**, hosted on the NRICH Project website.
2. Students in grades 3–5 can practice their skills at plotting the various routes Alice the snail can take to traverse a brick wall to visit Brian the snail, with **Snails' Trails**, hosted on the NRICH Project website.
3. Students in grades 4–5 can create a **Minecraft maze** and then program an AI to **navigate that maze** on its own.

> I'm excited about this project because students, especially younger students, need more interaction with maps and navigation. I would use this in my 5th grade class because it incorporates many skills and standards. Each activity builds on the last and the extension activities offer great ideas if students' interest is piqued.
>
> — Kaitlin Snow Kohn, 5th Grade Teacher
> Whittier Elementary School

Glossary

algorithm: a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

artificially intelligent robot (AI robot): a robot that is able to use sensors to collect information and make autonomous decisions about how to complete a task even in a changing environment.

autonomous: having the capacity to act independently or without external control.

bias: preference for or against an idea or thing.

data: information.

database: storage for data, often shown in a table with rows and columns.

dataset: collection of data.

digits: numbers 0 to 9.

extraction: the action of identifying or separating out.

feature: unique measurable property.

image recognition: the ability of a computer program to analyze the pixels in an image and identify objects, people, or other subjects.

machine learning algorithm: a process or set of rules used by a computer to find and apply patterns in data.

natural language processing (NLP): the AI technology used to understand and interact with human language.

robot: a machine that is able to perform complex tasks automatically.

sense: a faculty, such as sight, hearing, or touch, used by people or animals to perceive information.

sensor: a device that allows a machine to perceive the natural world.

symbolic representation: a data representation or model that humans can understand.

training data: examples used to teach a machine learning model.

APPENDIX A

Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and Baymax from "Big Hero 6."

Learn More

Video: "**What is Artificial Intelligence (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**." This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision-making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "**An Ethics of Artificial Intelligence Curriculum for Middle School Students**"

Video: "**Algorithmic Bias and Fairness #18**"

Article: "**Ethical Concerns of AI**"

Article: "**Top 9 ethical issues in Artificial Intelligence**"

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

APPENDIX B

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Standards for Students																
Empowered Learner	x	x					x			x	x	x	x		x	x
Digital Citizen					x			x			x			x		
Knowledge Constructor	x		x	x		x	x	x			x		x			
Innovative Designer		x	x				x		x	x					x	x
Computational Thinker			x	x	x		x		x		x		x	x	x	x
Creative Communicator					x	x		x			x			x		
Global Collaborator							x					x	x			

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
ISTE Computational Thinking Competencies																
Computational Thinking (Learner)				x	x	x	x		x	x	x	x	x		x	x
Equity Leader (Leader)					x	x	x	x							x	x
Collaborating Around Computing (Collaborator)	x			x			x					x	x			
Creativity and Design (Designer)	x	x	x	x				x	x	x	x			x	x	
Integrating Computational Thinking (Facilitator)		x	x				x		x	x				x		

Guide	Elementary				Secondary				Electives				Computer Science			
Project	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
AI4K12 Five Big Ideas in AI																
Perception	x	x			x					x		x			x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x	
Learning	x			x		x	x				x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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